FG

ADA029432

FINAL REPORT

Monitoring Military Dogs

By Biotelemetry

DADA 17-72-C-2054

Prinicipal Investigator: Harry A. Gorman, D.V.M., M.S.

Surgical Laboratory

Department of Clinical Sciences

College of Veterinary Medicine and

Biomedical Sciences

Colorado State University

Fort Collins

September 30, 1974

DDC
RECEIVED
SEP 10 1976
A

Approved for public release; distribution unlimited

409836

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

(6) MONITORING MILITARY DOGS BY BIOTELEMETRY.

5. TYPE OF REPORT & PERIOD COVERED

(9) FINAL rept.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) Harry A. Gorman ~~D.V.M., M.S.~~

8. CONTRACT OR GRANT NUMBER(s)

(15) DADA 17-72-C-2054 NEW

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Surgical Laboratory
Department of Clinical Sciences
College of Veterinary Medicine and Biomedical Sciences
Colorado State University, Fort Collins, CO 80523

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

(11) 30 Sep 74

11. CONTROLLING OFFICE NAME AND ADDRESS

Department of the Army
U.S. Army Medical Research & Development Command
Washington, D.C. 20314

12. REPORT DATE

September 30, 1974

13. NUMBER OF PAGES

approximately 70

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

(12) 108p.

15. SECURITY CLASS. (of this report)

unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

none

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

none

DDC
RECEIVED
SEP 10 1976
A

18. SUPPLEMENTARY NOTES

none

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Introduction
Project Development
Configuration of Transmitter & REceiver
Operation Instructions
Heart Rate Study
Physiology Data Graphic Display
Sensors
Surgical Techniques
Electronics
Data Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

see attached.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

409836

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

B

unclassified

BLOCK 20

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

A study was undertaken by the Surgical Laboratory at Colorado State University under a contract issued by the Research and Development Command of the United States Army to develop a telemetry package for monitoring trained scout dogs under field conditons and to study physiologic activity of these dogs in response to allerting on hidden quaries.

A complete two channel telemetry system with one channel of physiologic data and one alert information channel was designed, built, and tested. The physiology channel transmitted the electrical activity of the heart. The alert channel transmitted an alarm signal activated by a sitting alert position switch or by a redundant pull switch mechanism. The completed system included a transmitted and receiver alert switching mechanisms, heart rate electrodes, antenna, receiver carrying pack, transmitter carrying saddle, and internal power supplies.

The heart rate activity study evaluated the changes in heart rate of trained military dogs during alerting responses to hidden quaries including trip wires, pungi pits, cashes, and human decoys. As a measure of rate, the electrical activity of the heart was recorded using external paste-on electrodes and a small medical tape recorder carried by the dog. The recorded information was transferred to strip chart paper printout for interpretation and analysis.

ACCESSION for

NTIS

DDC

UNANNOUNCED

JUSTIFICATION

BY

DISTRIBUTION/

Dist.

A

Table of Contents

MONITORING MILITARY DOGS BY BIOTELEMETRY

Phase I

Phase II

PHYSIOLOGIC MEASUREMENTS (Extension of Contract) DADA 17-72C-2054

Table of Contents

For Figures

Military Dogs

Monitoring by Biotelemetry

Phase I

I. INTRODUCTION

A study was undertaken by the Surgical Laboratory at Colorado State University under a contract issued by the Research and Development Command of the United States Army to develop a telemetry package for monitoring trained scout dogs under field conditions and to study physiologic activity of these dogs in response to alerting on hidden quaries.

A complete two channel telemetry system with one channel of physiologic data and one alert information channel was designed, built, and tested. The physiology channel transmitted the electrical activity of the heart. The alert channel transmitted an alarm signal activated by a sitting alert position switch or by a redundant pull switch mechanism. The completed system included a transmitter and receiver alert switching mechanisms, heart rate electrodes, antenna, receiver carrying pack, transmitter carrying saddle, and internal power supplies.

The heart rate activity study evaluated the changes in heart rate of trained military dogs during alerting responses to hidden quaries including trip wires, pungi pits, cashes, and human decoys. As a measure of rate, the electrical activity of the heart was recorded using external paste on electrodes and a small medical tape recorder carried by the dog. The recorded information was transferred to strip chart paper printout for interpretation and analysis.

II. PROJECT DEVELOPMENT

A. ELECTRONICS DEVELOPMENT--TRANSMITTER

Phase I Transmitter System: A two channel FM/FM transmitter with one channel capable of continuous physiological data transmission and one channel for the "alert" signal was designed and built for study. The complete transmitter end of the telemetry system including the transmitter, mercury positional switch with delay circuit, redundant pull switch, battery power supply, antenna, on-off switches, and the necessary interconnecting wiring was laid out and assembled in breadboard fashion for testing (Figure 1).

An initial attempt at design and production of mercury position switch using three oval mercury bubbles resulted in a highly sensitive switch. This switching mechanism was connected to an alarm signal through a ten second delay circuit. The delay circuit is an essential element in this alarm mechanism to prevent false signals due to mercury movement or to uneven terrain. Testing indicated that this switch design possessed excessive sensitivity for its intended use. Several modifications were attempted without achieving the desired configuration. This design was therefore abandoned and a commercially available electric mercury switch with an adjustable sensitivity was obtained, tested, and found to be suitable.

Testing of this unit indicated that the basic concept of one heart rate monitoring channel with a second alert channel activated by a positional mercury switch and redundant pull switch was a feasable system.

Packaging was not considered at this stage and the transmitter assembly was left in the breadboard configuration.

Phase II Transmitter System: The original transmitter segment of the monitoring system was modified by incorporating a "Darlington" circuit into the amplifier of the physiological data channel to increase the audio gain. This circuit modification

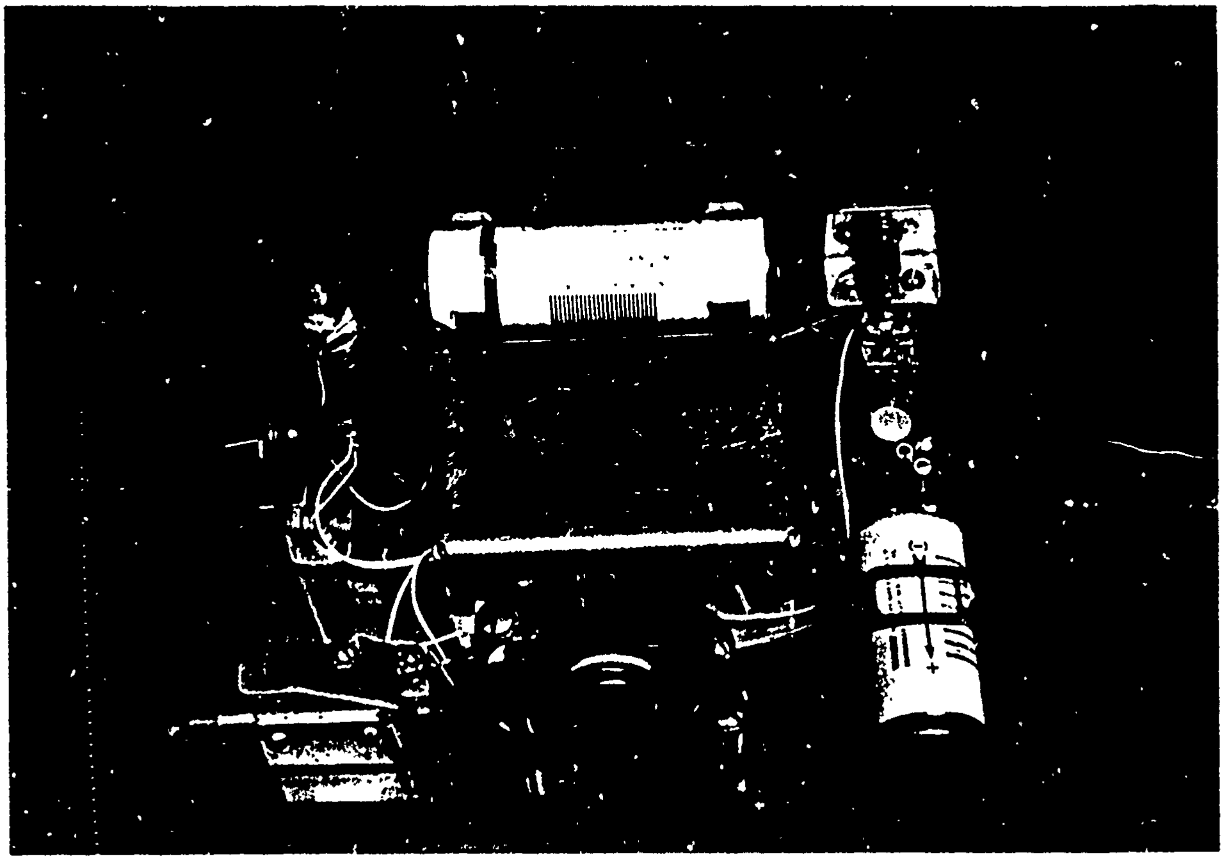


Figure 1 - Phase I Transmitter System Breadboard: a) transmitter circuitry; b) mercury positional switch; c) mercury switch delay circuit; d) main power source; e) mercury positional switch delay circuit battery; f) on-off switch; g) silent mode to ECG monitor switch; h) redundant pull switch; i) antenna; j) ECG lead connector.

also increased the transmitter impedance to a value more compatible with the silver-silver chloride external electrodes being used for monitoring of heart rate.

The layout of the system was modified to reduce its size and weight. To accomplish this, one of the power sources was removed, the mercury positional switch delay circuit was incorporated on the transmitter circuit board, and the switch arrangement was modified (Figure 2).

The complete monitoring system was still larger than the desired final configuration. Packaging was done, however, to allow field testing of the system. The package for this Phase II System was constructed from a high density particle board with dimensions of 7 3/4" x 4 1/2" x 1 3/4" and weighing 1 1/2 lbs. (Figure 3).

Phase III Transmitter System: Circuit layout and component modifications of the Phase II Transmitter System resulted in greatly reduced size of the Phase III Transmitter System. The size and weight of this unit was compatible with the requirements for a field use system.

The electronic circuitry of the final system utilized a preamplifier providing high input impedance and high common mode immunity for the ECG signal, an amplitude modulated transmitter and a 15 second delay circuit for the alert switching mechanism. The ECG signal is amplified and drives a modulator which varies the supply voltage of the transmitter. The resulting voltage fluctuations produce amplitude modulation of the transmitted radio-frequency signal. The AM transmitter section is a crystal controlled oscillator operating in the 89 mHz band with a tuned tank circuit in the collector to provide power to the antenna. By crystal controlling the transmitter long-term carrier, frequency shift can be eliminated.

The alarm circuitry consists of a mercury switch, time delay circuit, redundant pull switch, and oscillator. The mercury switch is adjustable and is positioned so that when the transmitter package is at an angle compatible with the sitting position of the dog the switch contacts are closed. A fifteen second time delay is

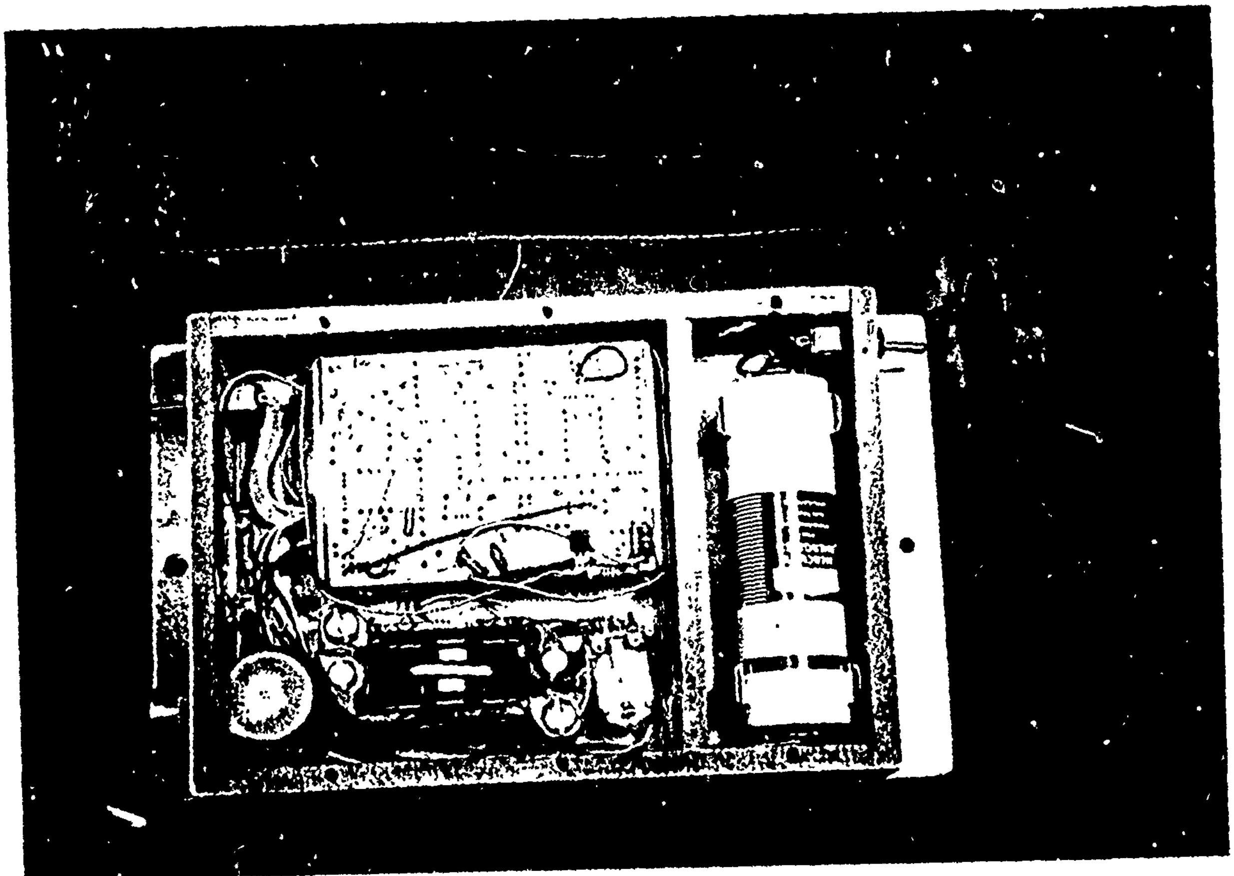


Figure 2 - Phase II Transmitter System Layout: a) transmitter circuitry; b) mercury positional switch; c) power source; d) on-off switch; e) silent mode to ECG monitor switch; f) redundant pull switch; g) ECG lead connector.

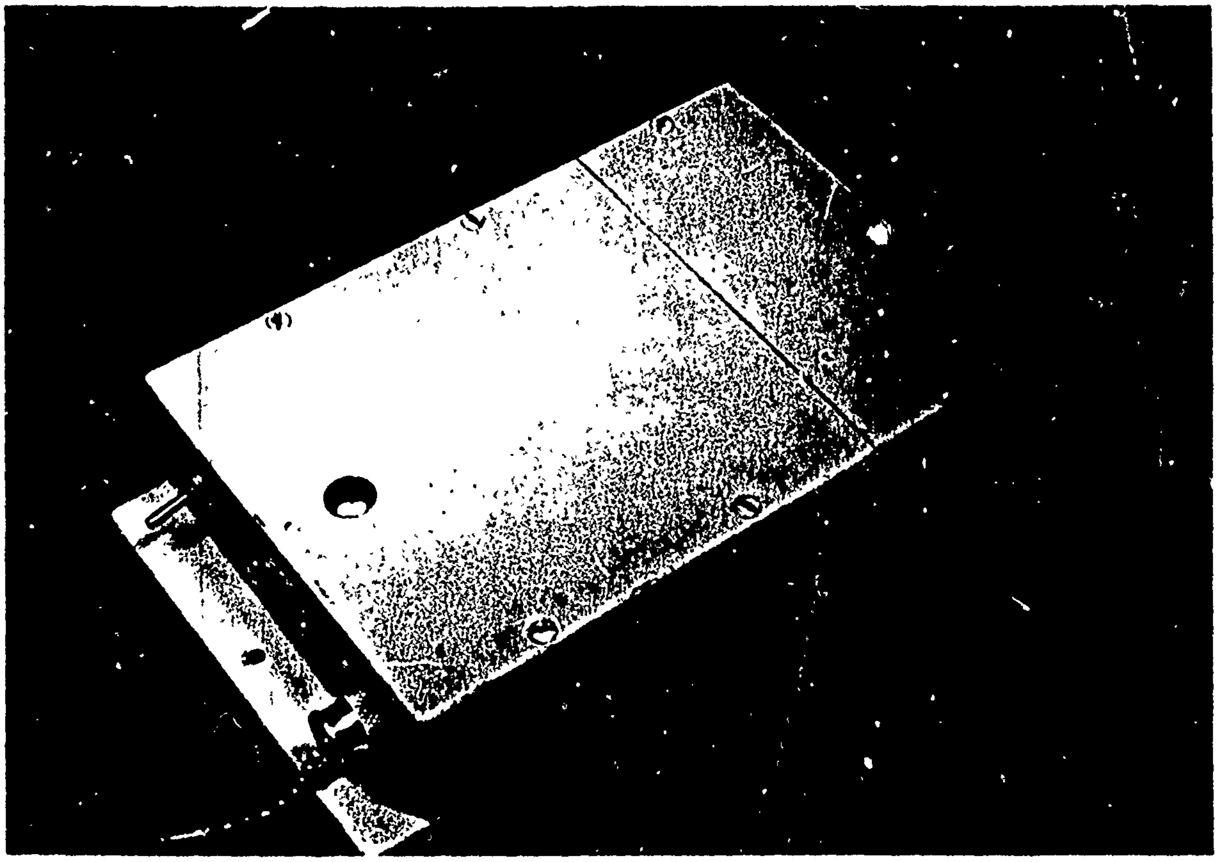


Figure 3 - Phase II Transmitter Package: a) silent mode to ECG monitor switch; b) ECG lead connector; c) redundant pull switch; d) battery compartment cover.

used to eliminate false positive alert signals due to alterations in terrain and due to sloshing of the mercury with movement of the dog. This alarm delay circuit functions as follows: the battery voltage is always present at one contact of the mercury switch, as soon as the switch contacts are closed the voltage is applied to the collector of the time delay circuit and at the end of the fifteen second delay period voltage is provided to the oscillator circuit. If the mercury switch contacts are opened prior to completion of the delay period, the delay is reset to fifteen seconds. Oscillator circuit excitation may also be accomplished by closure of the redundant pull switch resulting in immediate activation of the oscillator without a delay period. When the alarm oscillator circuit is activated, modulation of the transmitter section occurs and the "alert" tone is transmitted to the dog handler.

The audio frequency of the Phase I and II Transmitters was high pitched and unsuitable for prolonged listening. The frequency utilized in the Phase III Transmitter was therefore changed to provide a more pleasant signal tone.

The transmitter package has been reduced in size from the original cumbersome 6" by 8" breadboard model to a 6" by 2" by 1" unit weighing 3/4 lb. The case for the transmitter is contructed of 1/8" aluminum channel stock. A 9 volt, commercially available transistor battery, with snap connections is the power source. This battery is contained in one end of the transmitter package in a spring loaded compartment with an easily removable cover plate (Figure 4).

B. ELECTRONICS DEVELOPMENT -- RECEIVER

Phase I Receiver: The initial development of the transmitter-receiver system was carried out using a fixed ground station receiving and recording system. The system was composed of an Eddystone multiband receiver with frequency capabilities of 19-165 mHz in both the AM and FM modes, a Data Control Systems multichannel frequency discriminator (IRIG standard), and a Sanborn multichannel stripchart

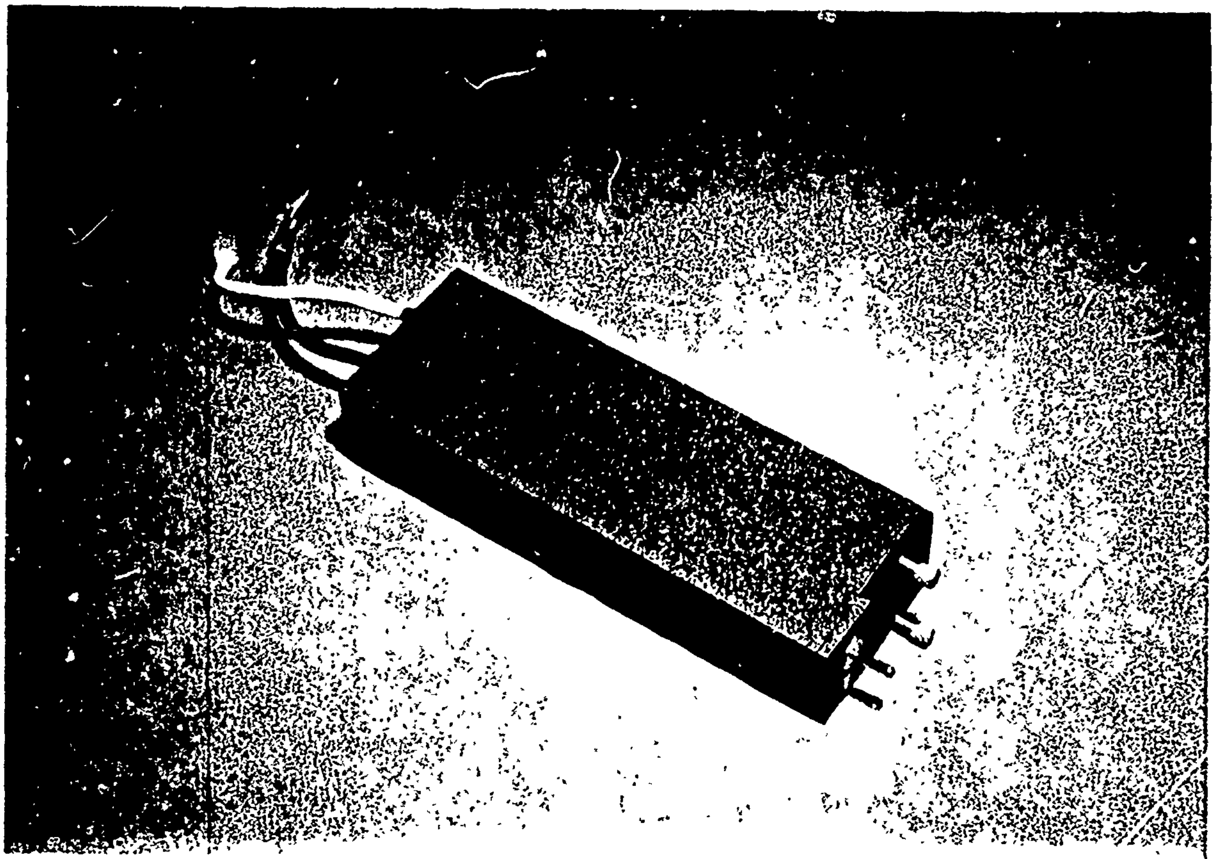


Figure 4 - Phase III Transmitter System Package: a) ECG monitor-off silent mode switch; b) battery compartment cover and thumb screws; c) antenna lead; d) redundant pull switch lead; e) mercury positional switch adjustment access screw; f) antenna adjustment access screw.

recorder. This provided the capability for audio monitoring of signal, direct write-out of heart rate and position data for visual observation and evaluation (Figure 5).

Phase II Receiver: The initial transition from the stationary Eddystone receiver to a portable configuration was accomplished with a commercially available portable multiband receiver (Panasonic model #RF-1600). This particular unit was selected because of its high sensitivity with the frequency band being used in this program.

Phase III Receiver: This Phase III Receiver was contructed from a commercially available AM/FM receiver to which a Wineguard preamp was added to improve sensitivity. This was accomplished but not to the specification desired so this receiver model was abandoned. Another receiver having a sensitivity of five micro-volts was selected and tested. This receiver performed to a distance of up to 200 feet and was adapted for use in the system (Figure 6). As a result of final testing of the system, it was concluded that to extend the range of operation a receiver with a sensitivity of one microvolt or less would be required. The receiver was packaged in a plexiglass case with the antenna, headphone jack, and control knob on the top for easy use.

C. ANTENNA DEVELOPMENT:

The antenna design utilized with the Phase I and Phase II Transmitters was a simple straight whip antenna. This design provided sufficient transmittion range for testing of the basic system components but was not adequate for the desired functional system range. Several antenna designs were tested with the Phase III Transmitter to determine the best configuration to provide an extended range capability and also be compatible with other requirements for the package. Antenna types that were designed and tested include: a folded dipole antenna that was curved down around

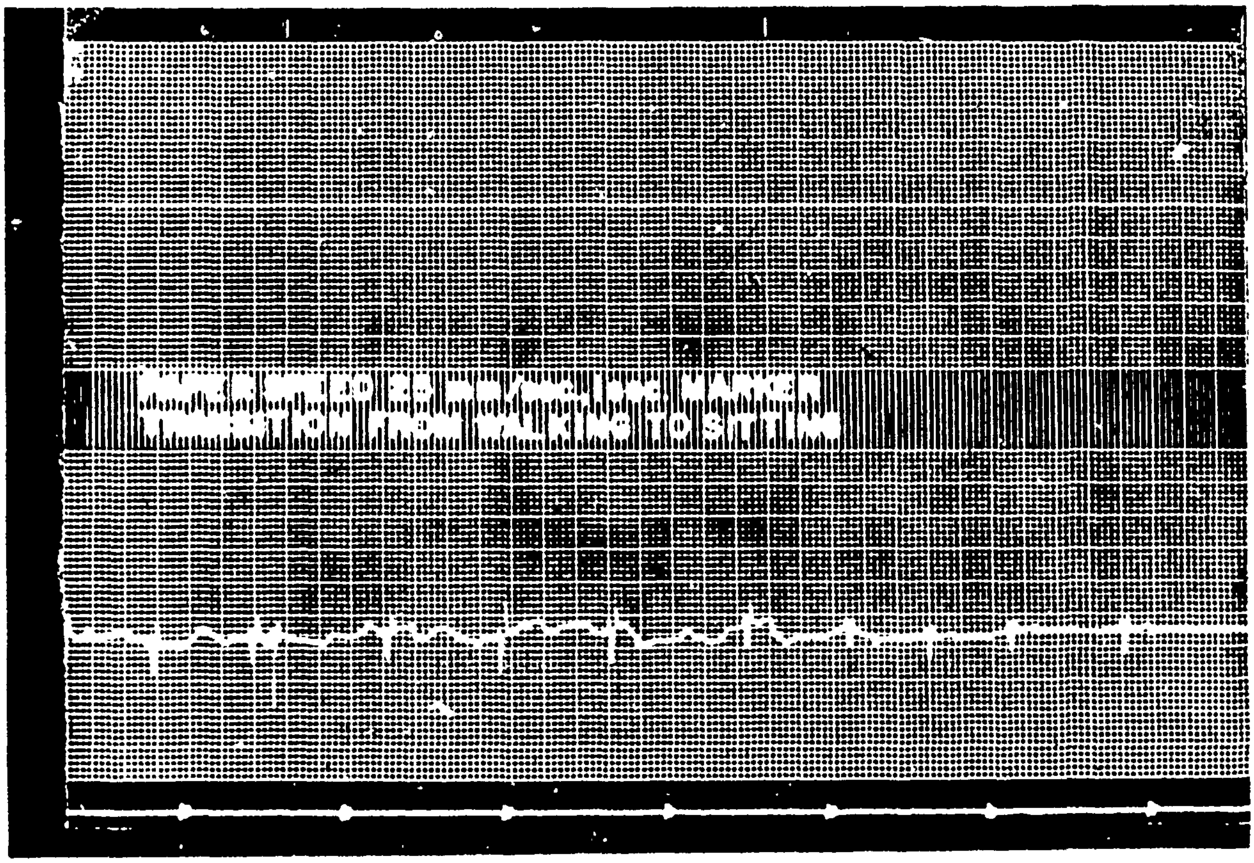


Figure 5 - ECG Tracing Utilizing the Phase I System: Recording during a preliminary telemetry study on November 29, 1971 showing the transition from walking to sitting.

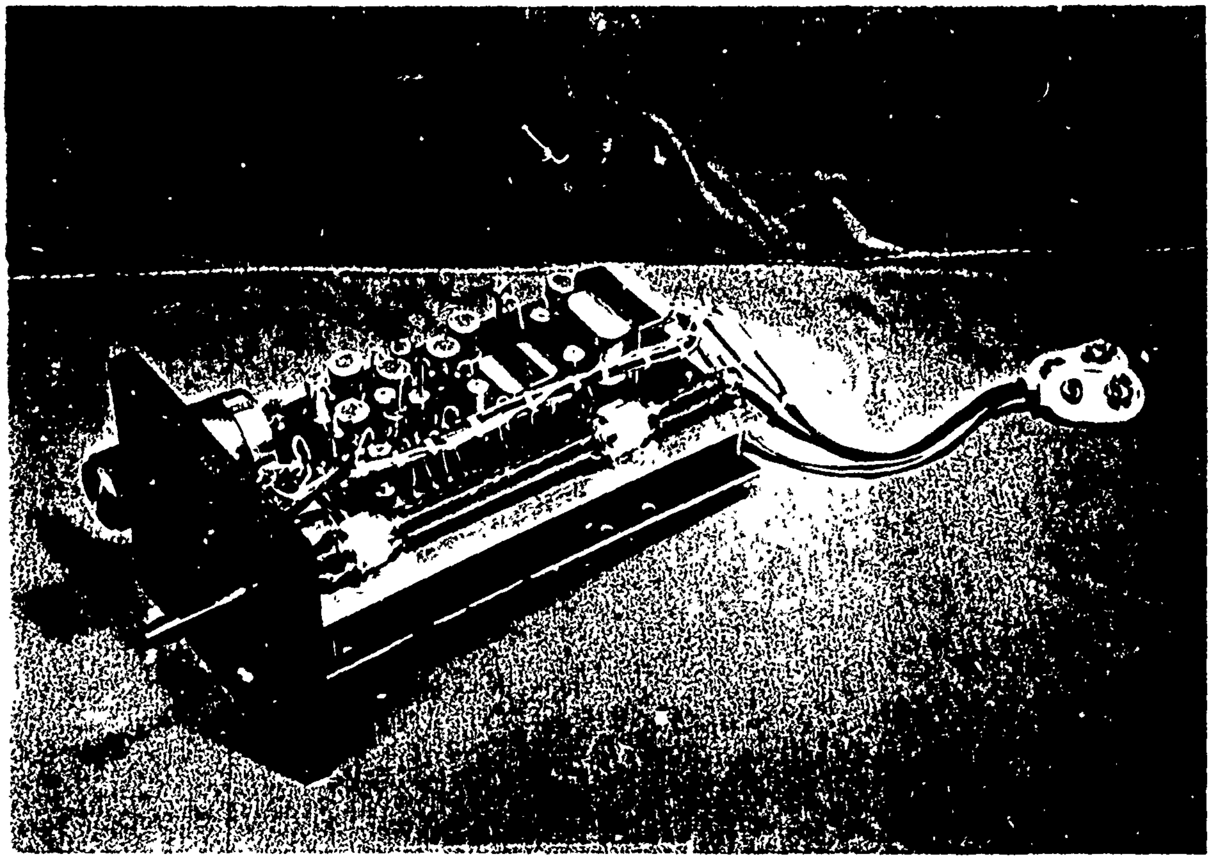


Figure 6 - Phase III Receiver System Layout: a) receiver circuitry; b) antenna; c) on-off volume control; d) headphone connector; e) battery connections.

the dogs body inside the saddle, a loop antenna, incorporation of the metal transmitter case as the antenna, and a straight whip antenna.

It was determined that the straight whip was the best suited design for use with this system. A tweleve inch spring steel antenna was therefore selected as the antenna design to be utilized on the final system package. This antenna was fixed to the top of the transmitter compartment of the Phase III Saddle pointing backward at an angle of about 30° from verticle. This design resulted in a strong streamlined antenna with some directional activity at the periphery of the transmission range.

D. PACKAGING DEVELOPMENT

Phase I Saddle Development: A stable platform for the transmitter that was light weight, durable, and was easily and comfortably worn by the dog were the desired characteristics for a saddle to be used on this project. The initial development of a form fitted saddle was accomplished using plastic orthopedic cast material. This material is a highly versatile substance that can be molded to any shape and then hardened by curing under a 3800 angstrom wavelength light. The hardened "cast" is lightweight, durable, water resistant, washable, it may be cut to shape and materials may be fastened to it with screws, bolts, rivets, or adhesive.

To form the first saddle, a body cast was made over the chest of an anesthetized German Shepherd dog from just behind the front limbs to the level of the last rib. The cast was removed by dorsoventral bivalving and was then trimmed to a suitable shape for the saddle. The two halves of the saddle were hinged together at the top and a platform was fixed to the top of the two halves. A harness of cotton webb strap material was riveted to the saddle. This saddle was designed for use with the Phase I Transmitter (Figure 7) and was also used with the Phase II Transmitter. The configuration of this saddle was adequate for initial testing, however, it failed to provide sufficient stability for the mercury positional switch.

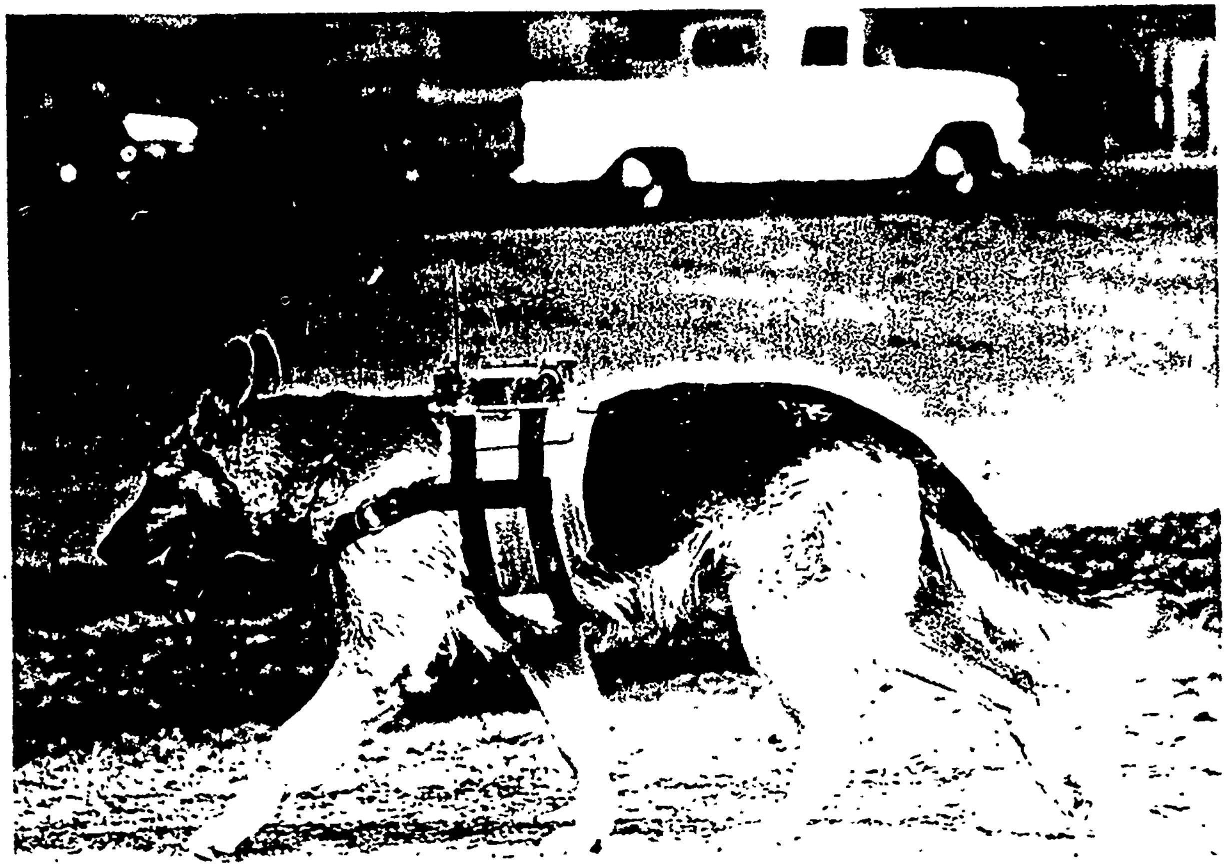


Figure 7 - Phase I Saddle in use with the Phase I Transmitter System.

Phase II Saddle Development: Lightcast was used in the contruction of the Phase II Saddle which was made over a mold as a one piece unit. The mold shape was taken from the Phase I Saddle and was modified to achieve a closer fit to the chest by using measurements taken from a standing awake German Shepherd dog. The saddle was extended further around the dogs chest to increase the rotational stability of the unit. Following removal from the mold, the saddle was trimmed to the desired shape and fitted with a harness. A platform and carrying compartment for the ECG recording unit used in the heart rate studies was contructed from lightcast and fastened to the top of the saddle.

This saddle was tested extensively in the field during the collection of the heart rate data for the physiology study phase of the project. The recording equipment used in this data collection weighed 3 1/2 lbs. which is far more than the 3/4 lb. weight of the final transmitter. Even with this increased load the saddle was well tolerated by trained scout dogs under field conditions with daily use for a period of two weeks.

One problem encountered with the saddle was a slight tendency to tip forward when the dogs were moving downhill. This was corrrected with a harness modification.

Phase III Saddle Development: The mold from the Phase II Saddle was used for construction of the Phase III Saddle. The final shape and harness configuration of the two saddles were the same, with the major difference between the two being the fiberglass material used in the Phase III Saddle. This change to fiberglass resulted in achievement of the desired end result of a light weight durable saddle that was comfortable for the dog and provided a stable platform for the transmitter unit.

Two methods were evaluated for construction of the transmitter carrier compartment. One method utilized ABS molded plastic which was then fastened to the top of the saddle. The other method used a fiberglass compartment molded as one piece with the lower portion of the saddle. The second method produced a one-piece

that was durable and had an excellent finished appearance. This all fiberglass saddle was selected for use in the final system.

To complete the saddle construction, several additions were required. A transmitter compartment cover was constructed from aluminum and fastened to the front of the transmitter compartment. This provided a door over the open front of the transmitter compartment to protect the transmitter, ECG connector and ECG lead wires. An access plate was constructed on the back of the transmitter compartment to allow access to the back of the transmitter for connection or disconnection of the antenna and redundant pull switch leads. The redundant pull switch was mounted on the left side of the transmitter compartment in the space behind the transmitter. The surface of the saddle that rides on the dog was lined with 1/2" thick foam padding material and then covered with leather. The antenna was bolted in place through the top of the transmitter compartment in the space behind the transmitter.

<u>ECG Lead Protection Vest</u>: During use of the transmitter unit under field conditions, it was found that the ECG lead wires were vulnerable to damage by brush through which the dog was working. This problem was corrected with a vest like garment that covered the dog from in front of the front limbs to the middle of the abdomen (Figure 8). Holes were made from the front limbs and a small hole was made in the top of the vest at the front edge of the saddle to allow for connection of the ECG lead to the transmitter. This vest was made out of a synthetic stretch fabric and a zipper was installed along the ventral borders of the vest to protect the ECG lead wires.

<u>Receiver Pack Development</u>: A leather pouch was designed and contructed to function as the carrier for the receiver portion of the telemetry system. The pouch was made out of heavy leather with dimensions to allow for easy insertion and removal of the receiver, yet hold the receiver firmly in place. A back pack harness

Figure 8 - ECG lead protection vest with ECG lead connector.

was contructed for the receiver carrier pouch. This harness was designed so that the receiver is carried high enough on the operators back to allow adjustment of volume and on-off switching without removal of the harness.

III. FINAL CONFIGURATION OF TRANSMITTER RECEIVER ELECTRONICS

A. FM TRANSMITTER DESCRIPTION

The FM transmitter pack is comprised of 7 sections as shown by the block diagram in Figure 9.

Section 1 is a high gain single ended AC amplifier. ECG signals of 1 MV to 5 MV are picked up and fed to the input of the amplifier by the electrodes and electrode leads. The MV signal is then amplified to a voltage level that will trigger a pulse forming circuit. This pulse of 5V is used to produce the modulation drive for the heart rate signal.

Section 2 is the position circuitry, consisting of Q_1 and Q_2 (for all component references see Figure 12) which delays the position tone for 15 seconds to prevent inadvertent keying. As the tone is keyed, the pitch will start to increase at a non-linear rate reaching a stable level at the end of 30 seconds. Keying the tone is accomplished by an adjustable mercury position switch, set to provide bias to the position circuitry when the dog is in a sitting position. Adjustment of the switch can be performed by rotating the switch with a sharp probe inserted through the access hole in the transmitter housing (Figure 10). This adjustment may be required with different terrain conditions or different dogs.

A redundancy switch is utilized to shunt the delay circuit. This switch is closed by the dog tugging on the switch pull chain. At the instant this switch is closed, a constant tone will be heard.

Section 3 is the tone oscillator and will require no adjustment. The steady state frequency is set to approximately 800 HZ. The tone generation circuitry consists of Q7, Q8, and Q9.

Section 4 is the transmitter modulator circuit. AM modulation of the transmitter is accomplished by controlling the bias current to Q14. Modulation section is comprised of Q10, Q11, Q12 and Q13. No adjustment of the circuit will be required.

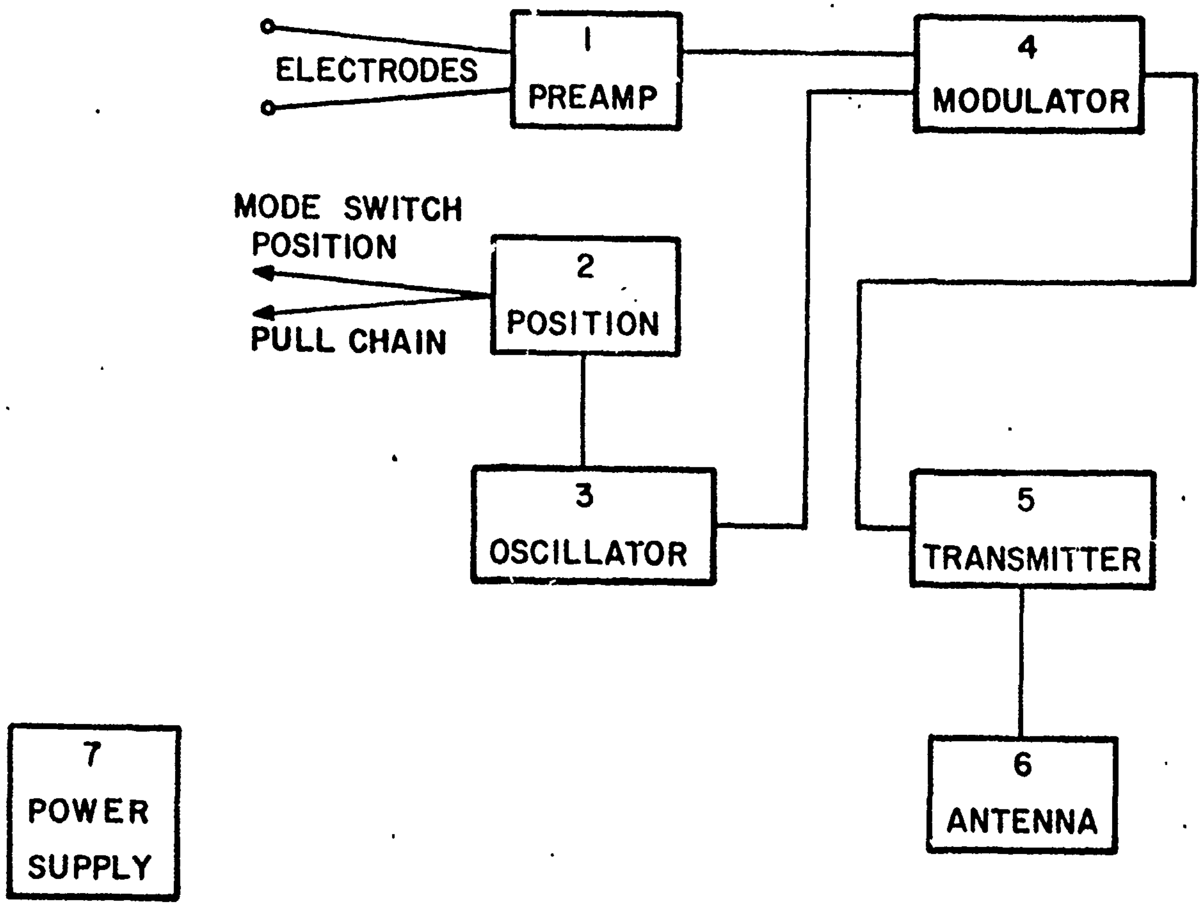


Figure 9 - Transmitter block diagram.

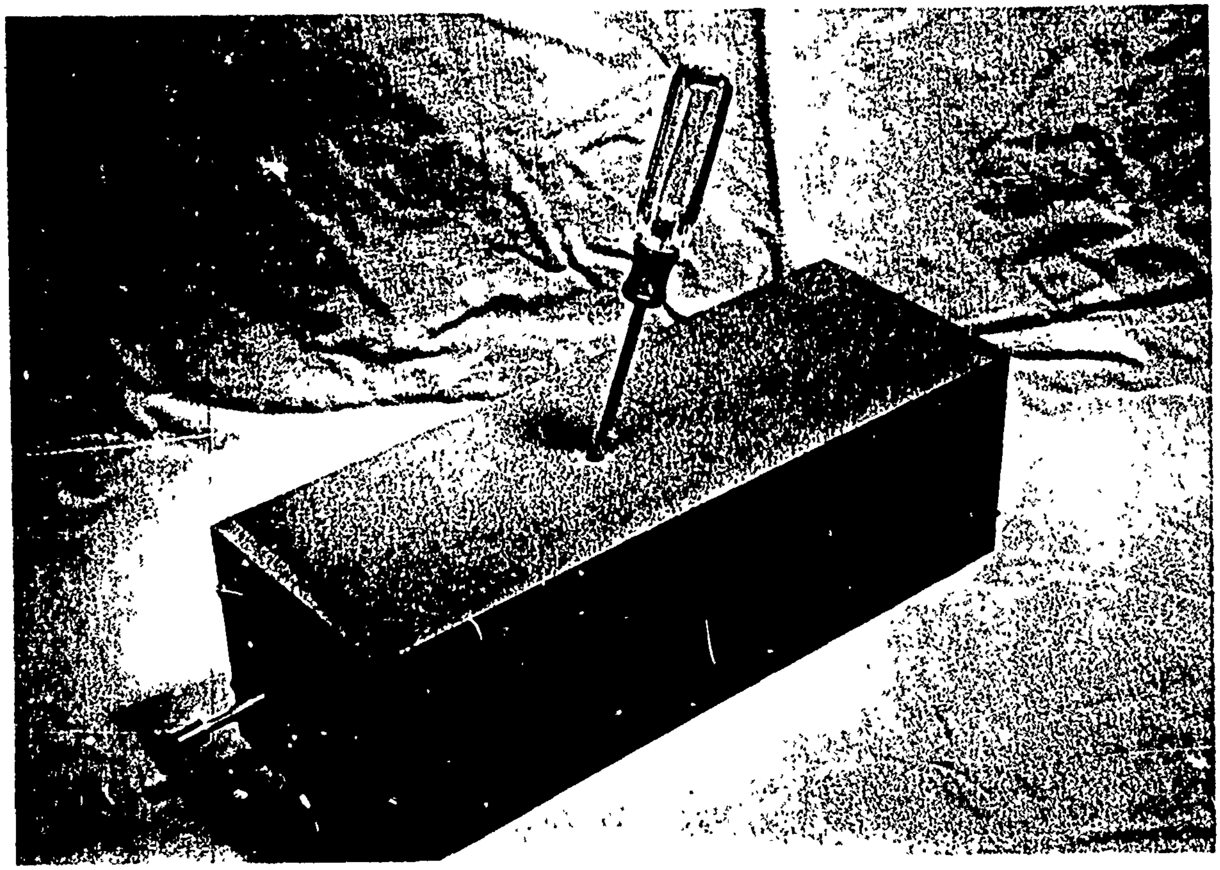


Figure 10 - Mercury positional switch adjustment technique: A pointed instrument is used to rotate the positional switch to achieve the proper sensitivity adjustment.

Section 5 is the power oscillator (Q14) or transmitter which is AM modulated. The circuit is crystal controlled and is currently adjusted for operation at 89 MHz. The oscillator frequency can be set by adjusting capacitor C18. This frequency setting may be checked from time to time by use of an electronic count or calibrated receiver.

Section 6 consists of the antenna coupling circuit and antenna. The secondary of L1 has been adjusted for an impendance of 50 ohms. Antenna length is cut to 1/8 of the wave length and matching is accomplished by adjusting capacitor C-20. Any change in transmitter components will require readjustment of C-20.

Section 7 is the transmitter power supply consisting of an Eveready #222 battery and decoupling capacitors C-8 and C-16.

B. FM RECEIVER DESCRIPTION

The FM receiver is of commercial origin and has been repackaged in a plexiglass case to fit the backpack harness. The receiver consists of 5 sections as shown in the block diagram (Figure 11).

Section 1 is a tuned RF amplifier which amplifies the incoming 89 mH radio signal.

Section 2 then converts the 89 MH- signs to the intermediate frequency of 10.7 MH-.

Section 3 is the IF amplifier circuit which amplifies 10.7 MH- signal to a level required for detection.

Section 4 is a ratio detector that decodes the 10.7 MH- signal by extracting the audio information.

Section 5 is an audio amplifier capable of delivering 350 mW of power. The amplifier is used to amplify the detected signal from 250 mV to a level sufficient to produce and output of 350 mW.

Section 6 is the receiver power supply consisting of two (2) Eveready #222 9V batteries. Two batteries have been used to power the R.F. and audio sections separately. This results in increased voltage stabilization and improved performance.

Information concerning alignment can be found in any readily available radio repair book.

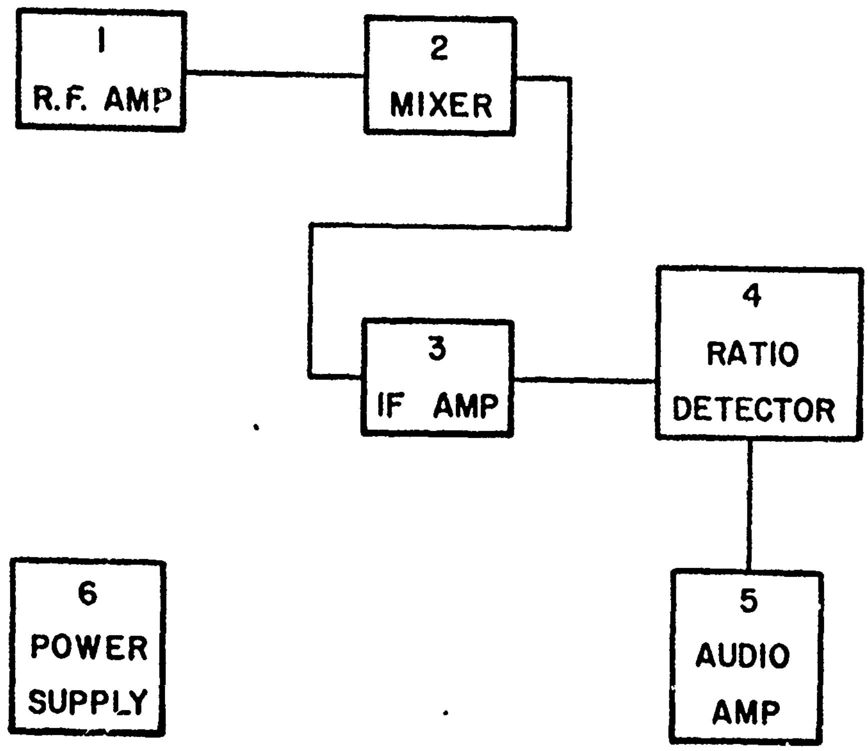


Figure 11 - FM Receiver block diagram.

C. TRANSMITTER AND RECEIVER SPECIFICATIONS

Table I

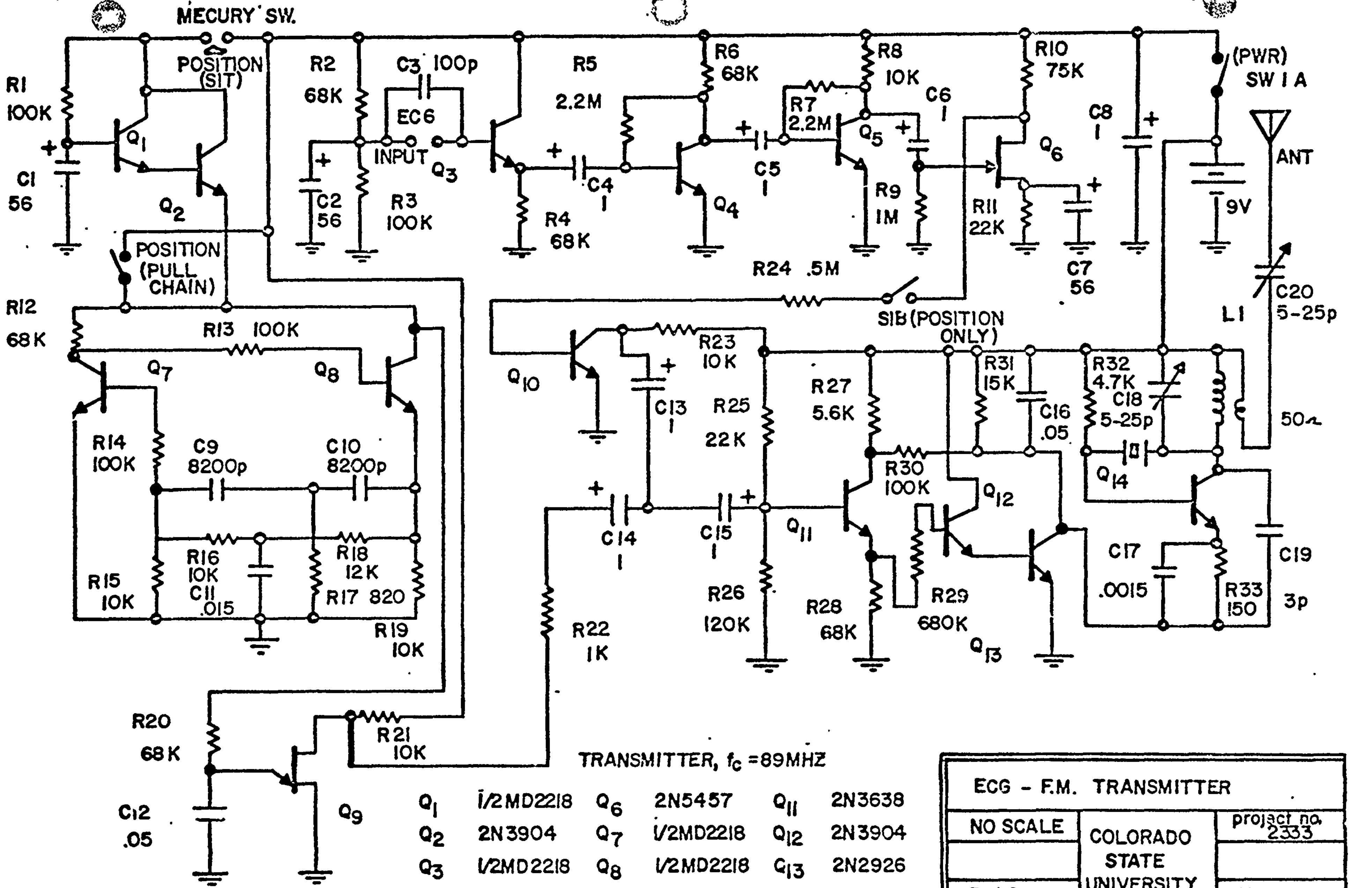
FM Transmitter

Frequency (crystal controlled)	89 MHZ
Power Output	50 mW
Modulation	FM
Signal Inputs	
1	Heart Rate Pulse
2	Sit Position, Increasing Tone To 800 HZ
3	Pull Chain Tone 800 HZ
Current Drain	30 mA
Battery	9V Eveready # 222

Table 2

FM Receiver

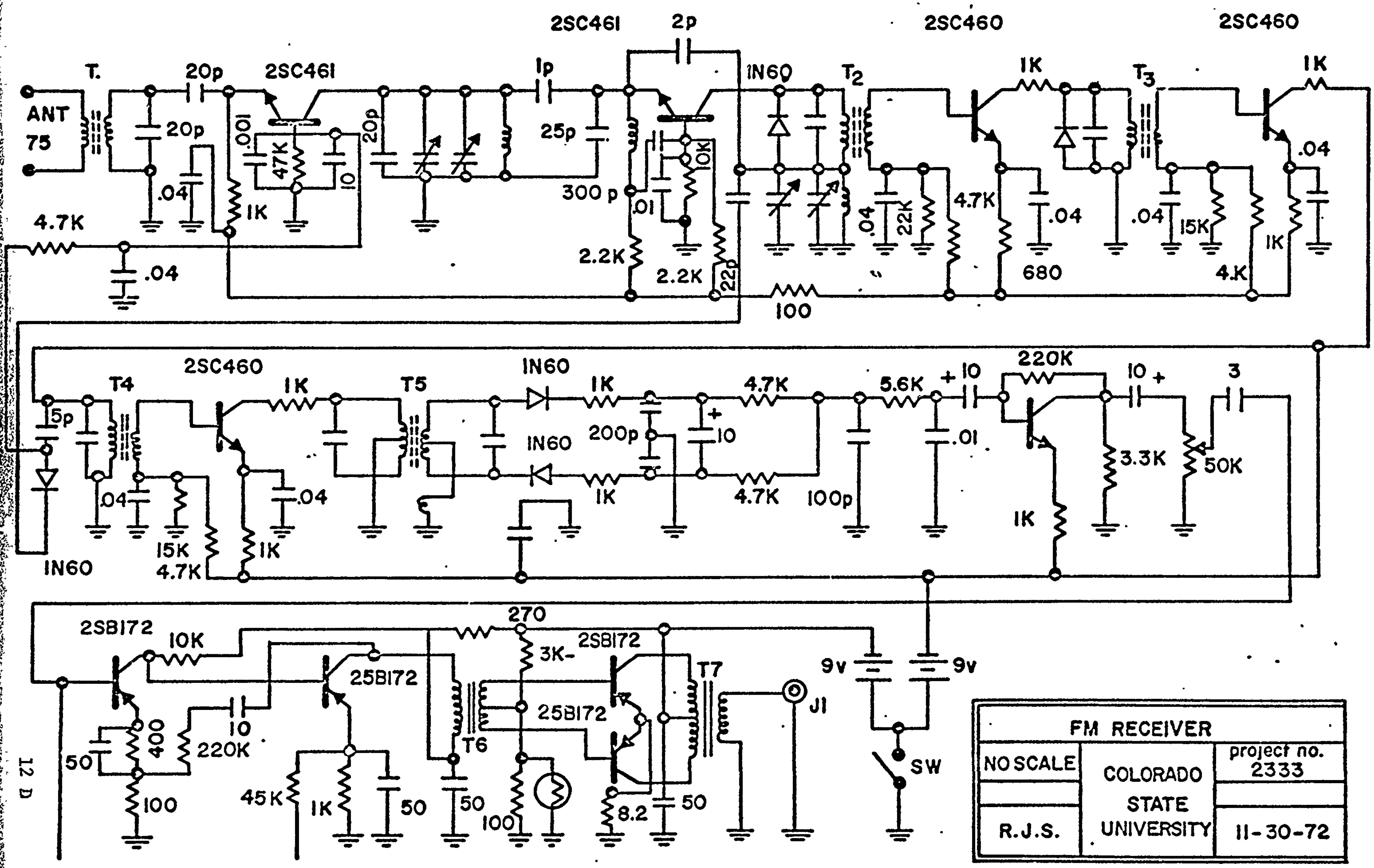
Frequency Range	88-108 MHZ
Antenna Input Impedance	75 OHMS
Sensitivity	5uv for 10db S + N/N
IF	10.7 MHZ
Current Drain	58mA avg.
Audio Gain	350 mW @ 1000 HZ into R_L = 8 OHMS
Frequency Response	± 1.5db 150-15,000 HZ
Battery	2 - 9V Eveready # 222



TRANSMITTER, f_c =89MHZ

Q_1	1/2MD2218	Q_6	2N5457	Q_{11}	2N3638
Q_2	2N3904	Q_7	1/2MD2218	Q_{12}	2N3904
Q_3	1/2MD2218	Q_8	1/2MD2218	Q_{13}	2N2926
Q_4	1/2MD2218	Q_9	UJT	Q_{14}	2N3663
Q_5	1/2MD2218	Q_{10}	2N3904		

ECG - F.M. TRANSMITTER		
NO SCALE	COLORADO STATE UNIVERSITY	project no. 2333
R.J.S		12-6-72


ANT
75
T.
20p
20p
.04
4.7K
.04
2SC461
.001
47K
10
1K
20p
1p
25p
300 p
2SC461
2p
.01
10K
2.2K
2.2K
22
100
IN60
T2
.04
22K
4.7K
2SC460
1K
680
.04
T3
.04
15K
4K
2SC460
1K
1K
.04
T4
5p
.04
IN60
2SC460
1K
.04
15K
4.7K
1K
T5
IN60
IN60
1K
1K
200p
10
4.7K
4.7K
100p
5.6K
10
.01
220K
10
3.3K
1K
50K
3
2SB172
10K
50
400
100
220K
10
25B172
45K
1K
50
270
3K-
T6
50
100
2SB172
25B172
8.2
50
T7
J1
9v
9v
SW
FM RECEIVER
NO SCALE
COLORADO
STATE
UNIVERSITY
project no.
2333
R.J.S.
11-30-72

12 D

IV. OPERATION INSTRUCTIONS

A. PREPARATION OF THE TRANSMITTER AND RECEIVER UNITS

1. The transmitter and receiver units should be checked for damage, wear, and contamination of the electrical connections before each use. The antenna-saddle connection and the access plate screws at the back of the transmitter compartment should be checked for loosening of its connection.

2. The transmitter battery should be replaced before each days use. To replace the battery, the transmitter compartment cover is raised and the transmitter is pulled foreward to the position shown in Figure 12. The two thumb screws on the battery compartment cover are loosened and the compartment cover is removed. The battery connection is spring loaded and when the compartment cover is removed the battery will pop foreward (Figure 13). If the spring mechanism does not work, the battery may be removed manually. The battery to transmitter connection is a double snap arrangement that must be properly aligned to make connection. The female connection of the battery must be toward the outside of the transmitter case. The battery is pushed into the case until the bottom of the battery is flush with the end of the transmitter housing and the compartment cover is replaced and fixed in place with the two thumb screws.

3. The receiver battery should also be replaced before each days use. This is accomplished by removal of the two thumb screws on the bottom of the receiver case. This releases the battery compartment. There are two receiver batteries loose within the compartment which may be removed easily by manual traction. The snap connectors may be pulled free of the receiver case for battery replacement. The battery-receiver connections are a double snap arrangement similar to those on the transmitter and must be properly matched to make electrical contact. Following replacement, the batteries are returned to the receiver case and the compartment cover is fixed in place with the two thumb screws.

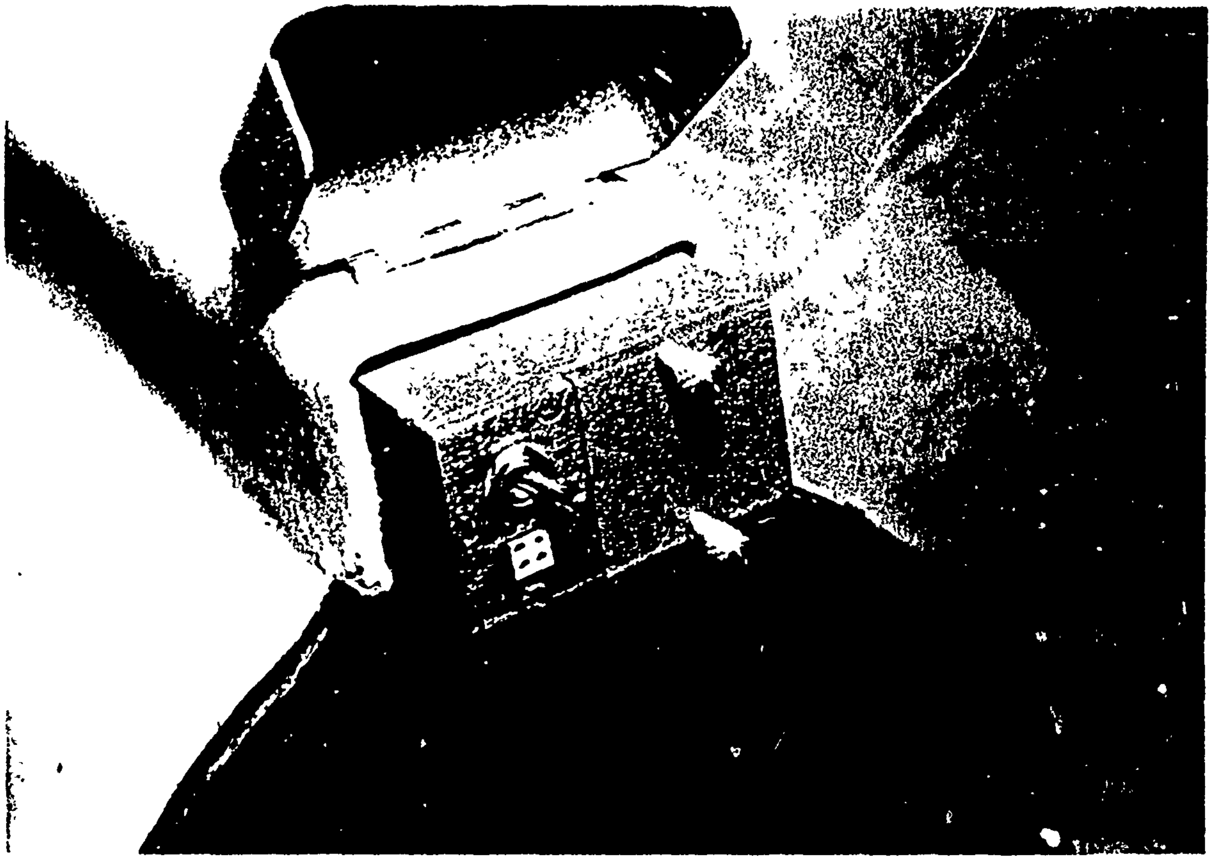


Figure 12 - Transmitter control identification: a) on-off transmitter mode selection switch; b) heart rate electrode lead input; c) battery e) transmitter carrier cover.

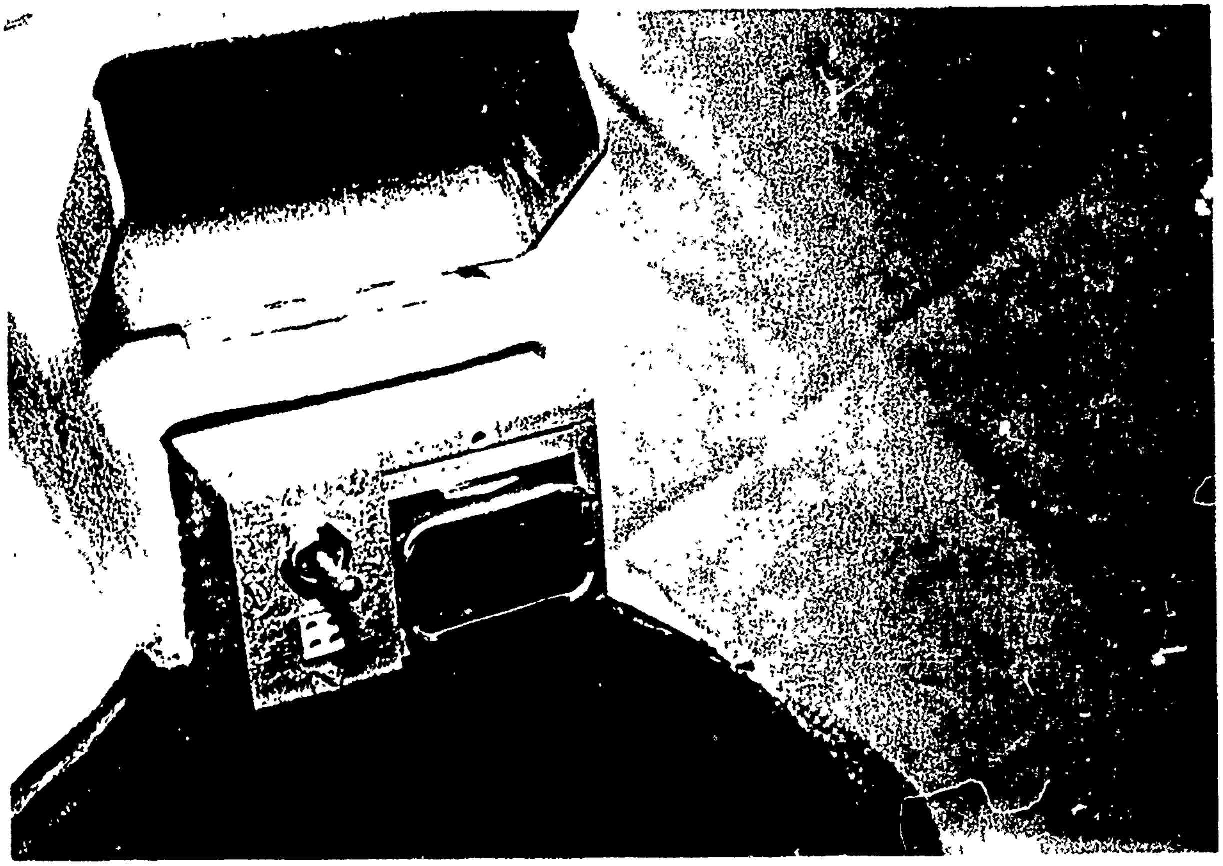


Figure 13 - Transmitter battery removal procedure: battery cover has been removed and the battery is in the popped-out position.

B. PREPARATION OF THE DOG

1. To prepare the dog for attachment of the electrodes, the hair is clipped from two sites on the dogs chest using an electric clipper with a fine #40 blade. An area about three inches by three inches is clipped clean on each side of the chest. The area on the left side is at the back edge of the rib cage and is centered about 1/4 of the way up on the chest. The area on the right side is behind the right shoulder blade about 2/3 of the way up on the chest (Figure 14).

2. The clipped areas are washed with mild soap to remove all dirt and debris.

3. The areas are shaved using a safety or straight razor to remove all exposed hair.

4. Following thorough cleaning and shaving, the areas are wiped with alcohol to remove fat and are then dried with clean dry sponges. It is important to have a clean dry surface to insure maximal adhesion of the electrodes.

5. The adhesive donut is lifted from the paper strip on which it is packaged and the exposed adhesive side is placed on the contact surface of the electrode. The hole in the adhesive donut must be centered over the recessed center portion of the electrode.

6. A small portion of EKG electrode paste is placed in the center recessed portion of the electrode contact surface (Figure 16). Enough paste should be placed in this recessed area to over fill it slightly and leave a small mound of paste above the level of the adhesive donut surface. The paste should not be allowed to spread out onto the adhesive donut as this will prevent the donut from adhering to the skin.

7. The paper cover on the exposed surface of the adhesive donut is now removed by lifting the blue tab (Figure 17). After removal of this cover the adhesive surface of the donut must not be touched. The electrode should be handled with the lead wire only (Figure 18).

8. The electrode is now placed face down in the center of the prepared area of skin and pressed into place (Figure 19). The exposed edge of the adhesive donut is

Figure 14 - Position for electrode placement on the right side of the dogs chest.

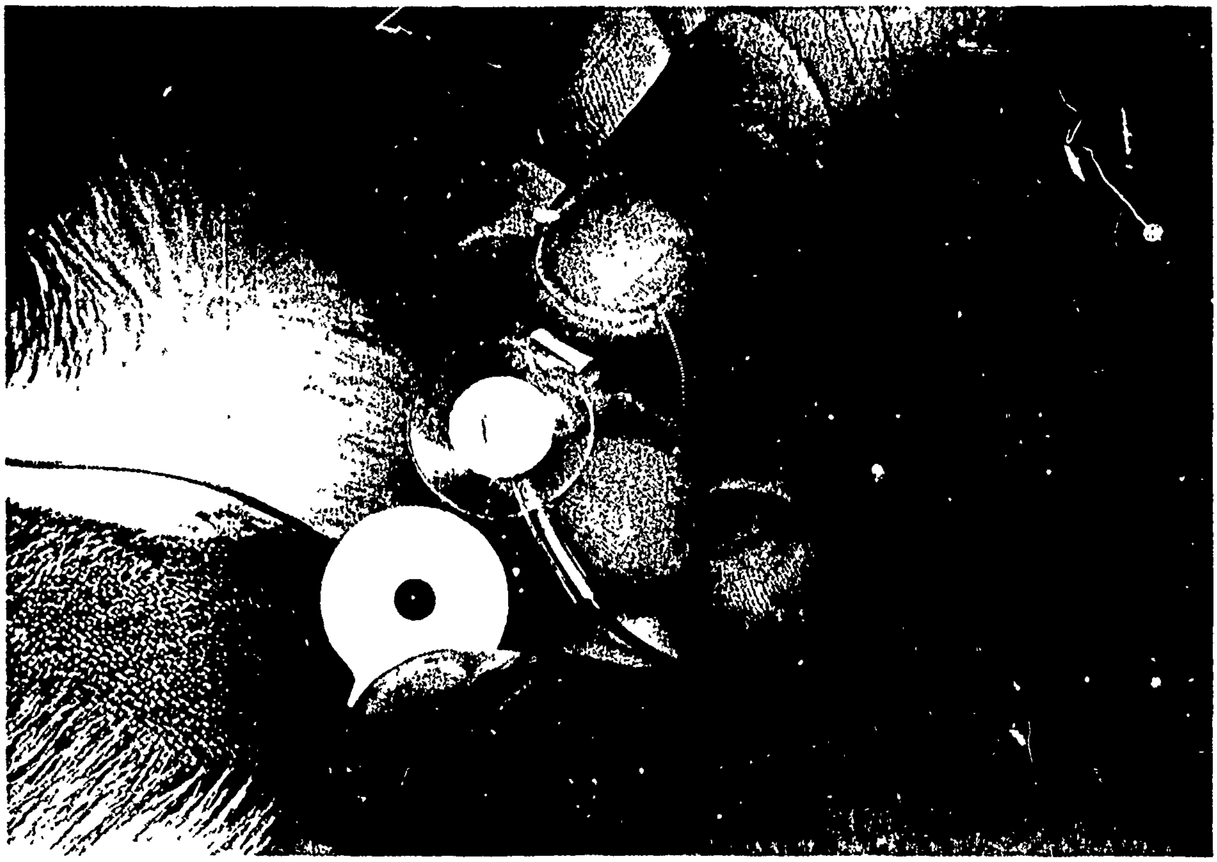


Figure 15 - Placement of the adhesive donut on the electrode.

Figure 16 - Application of the ECG paste to the center portion of the center portion of the electrode.

Figure 17 - Removal of the paper cover from the adhesive donut.

Figure 18 - Electrode and adhesive donut ready for attachment to the dog.

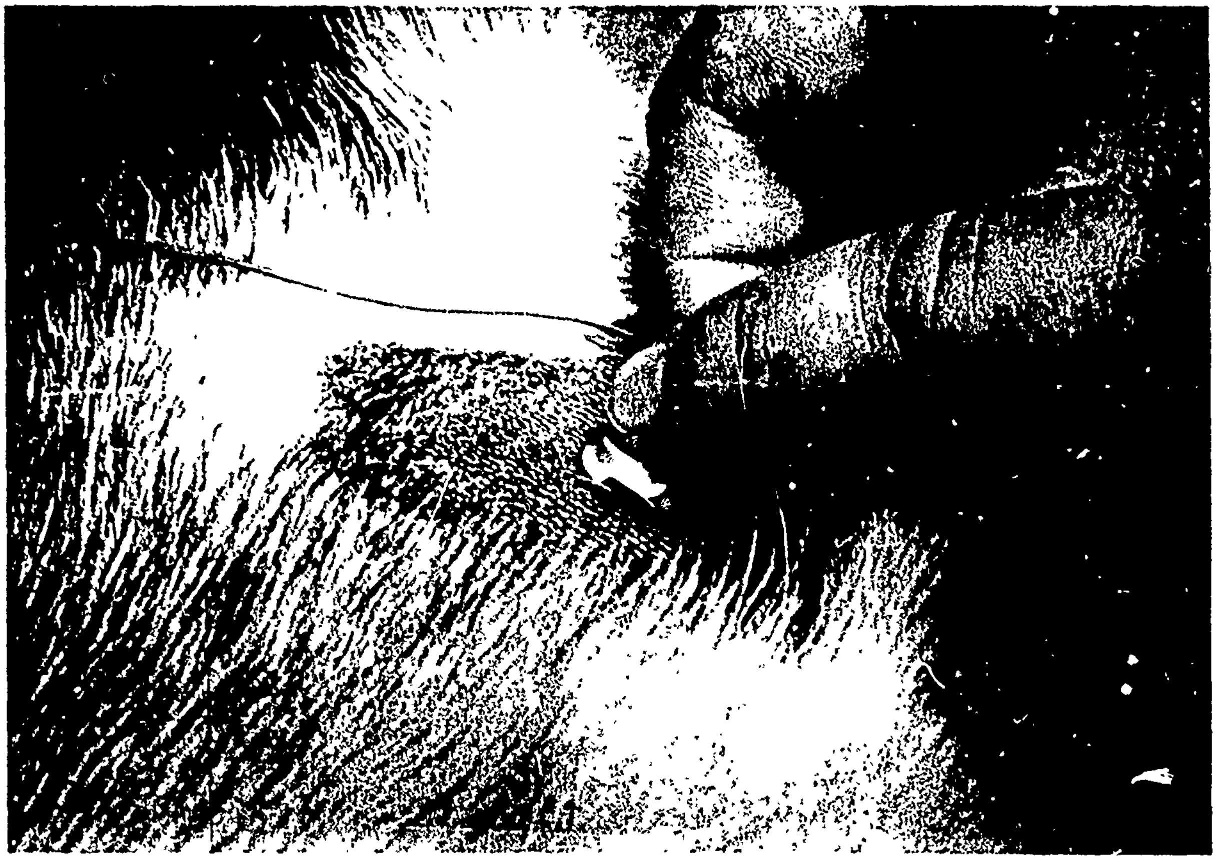


Figure 19 - Electrode placed on the dog.

pressed down at any loose points until a good bond is achieved.

9. The process is repeated for the second electrode. When placing the second electrode, the lead wires must be placed over the dogs back to allow for connection to the transmitter.

10. The black stretch vest is now placed over the dog and zipped in place. The lead wire connection is pulled through the hole in the top of the vest (Figure 20).

11. The saddle is placed on the dog with the transmitter compartment door facing forward and is fixed in place by fastening the three harness straps.

12. The transmitter compartment door is opened and an electrode lead connector is plugged into the transmitter (Figure 21).

The dog telemetry unit is now ready for use. If the dog is to be transported for some distance before being worked in the field, the saddle may be left off the dog until immediately before it is to be used.

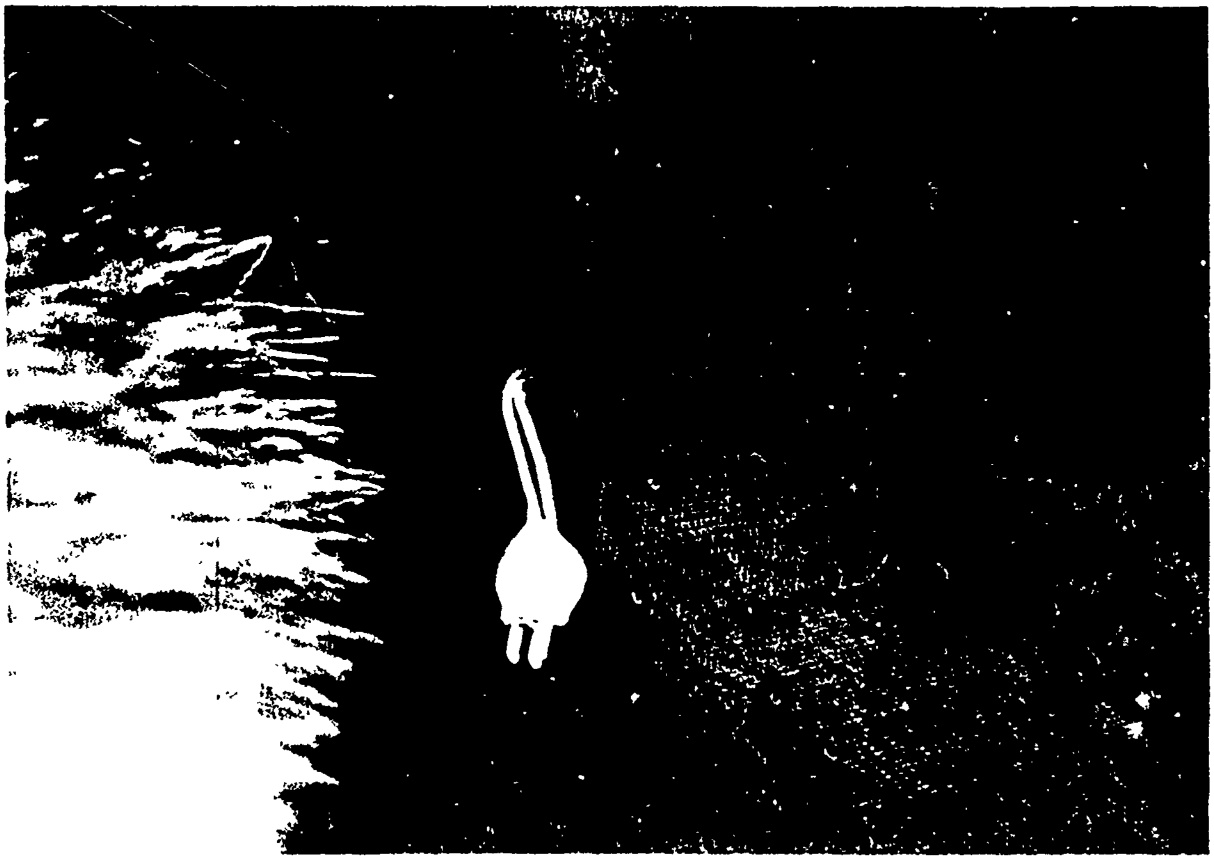


Figure 20 - The electrode lead connector in position with the lead protection vest on the dog.

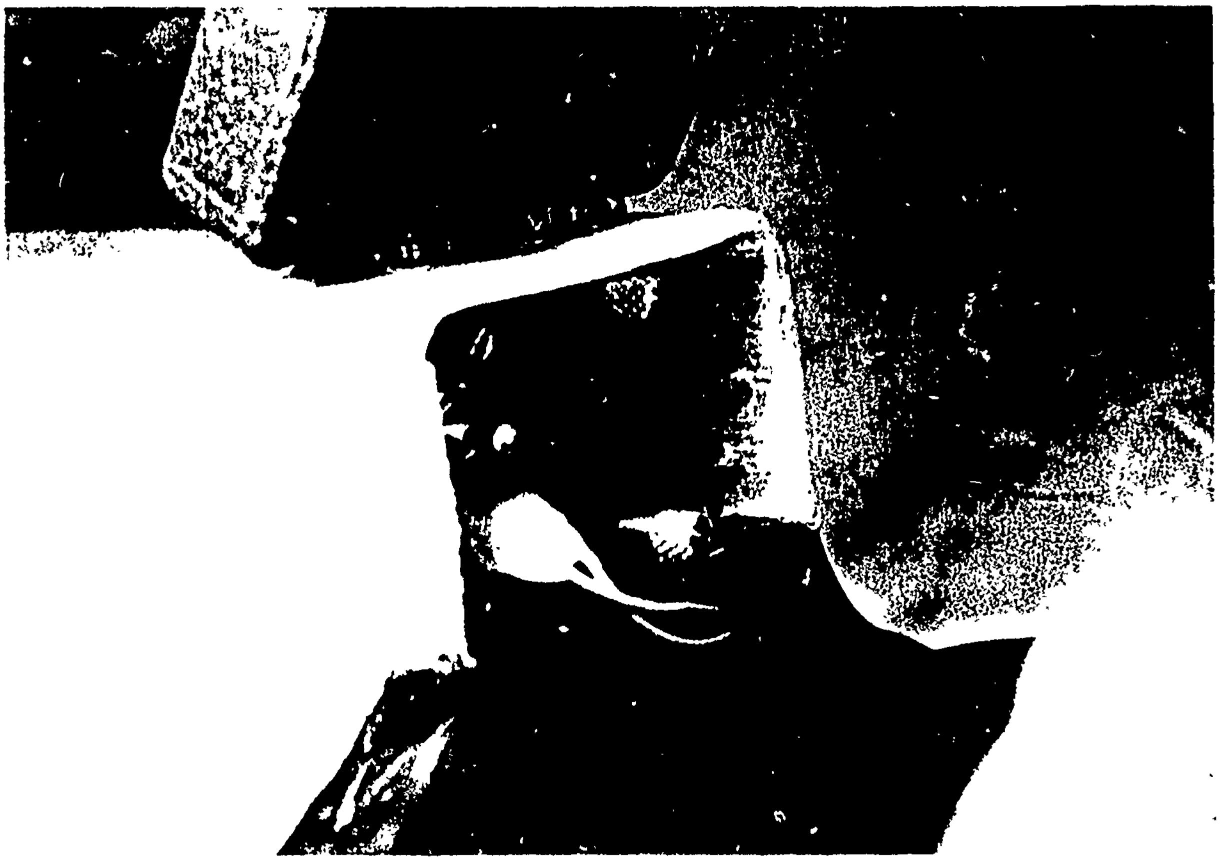


Figure 21 - Attachment of the electrode lead connector to the transmitter.

C. FIELD OPERATION

When the field location is reached where the dog will be worked, the transmitter compartment cover is lifted and the transmitter mode selector switch is moved to the on position in the desired mode. For the silent mode the switch is moved toward the left side of the dog and for the heart rate monitor mode the switch is moved toward the right side of the dog, The center position is the off position (Figure 22). Following activation of the system, the compartment cover is closed and the dog is released. The receiver unit is turned on and the volume is adjusted to the desired level.

Placement of the mode selection switch in the heart rate monitor mode will result in the dog handler receiving an audible "blip" every time the heart beats. The occurrence of an alert will be signaled by a high pitched siren like sound that has a changing pitch to a constant level if triggered by the sitting position switch mechanism. When in this mode changes in the heart rate can usually be detected by the handler when the dog alerts. Placing the mode slection switch in the silent operation position eliminates the audible "blip" of the heart rate but does not change the operation or transmitted sounds of the alert signal.

To deactivate the system following use, the transmitter compartment cover is raised and the on-off mode selector switch is placed in the off position. If the dog-telemetry system is to be reutilized, the transmitter compartment cover is closed and the telemetry package is left on the dog. To remove the package from the dog the transmitter compartment cover is raised, the on-off-mode selection switch is placed in the off position, the heart rate electrode lead connector is unplugged and the transmitter compartment cover is closed. The saddle is removed from the dog by loosening the harness and lifting the package up off of the dogs back. BE SURE THAT THE HEART RATE ELECTRODE LEAD CONNECTOR HAS BEEN DISCONNECTED BEFORE REMOVING THE SADDLE. The lead protection vest is unzipped and removed. The heart rate electrodes are removed by lifting the blue tab on the adhesive donut. The electrodes should not

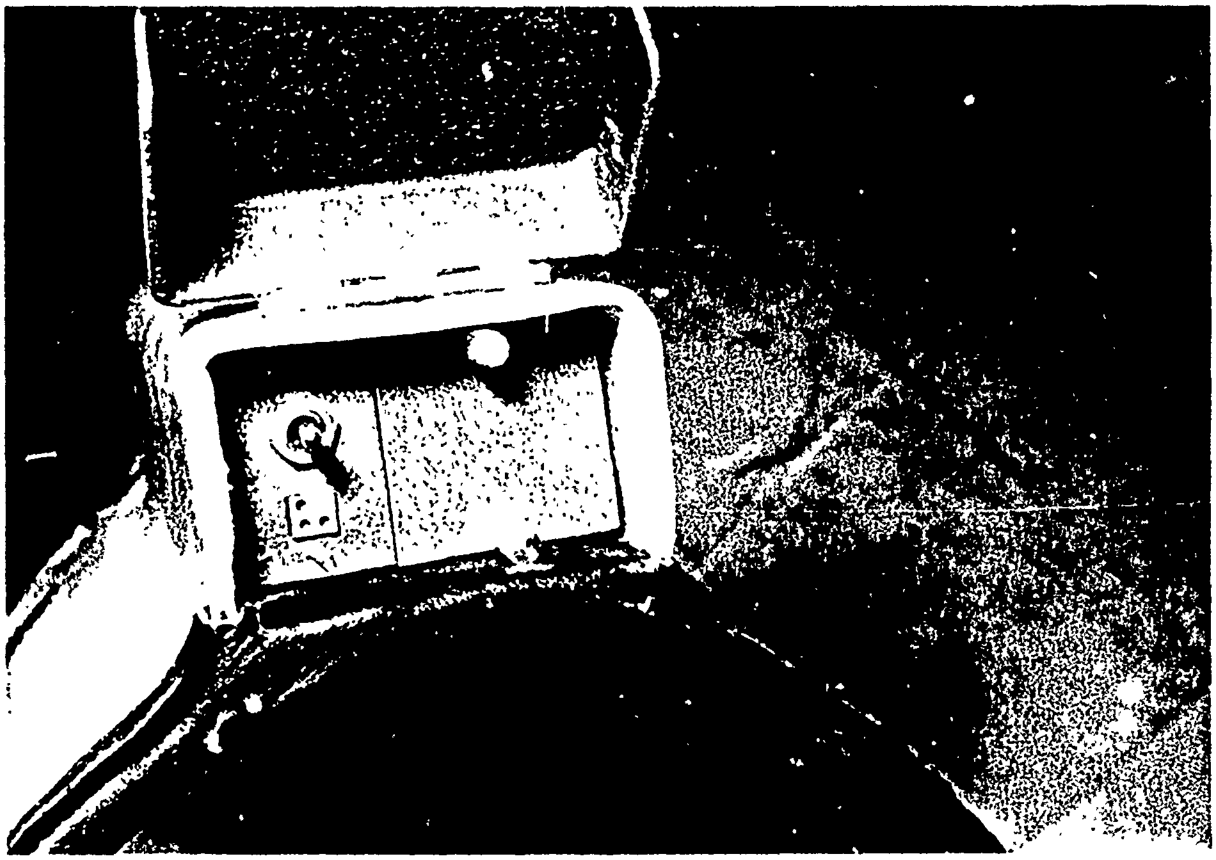


Figure 22 - The off position of the on-off-mode selector switch. The silent mode position is toward the left side of the dog; a) and the heart rate monitor position is toward the right side of the dog; b).

be removed by pulling on the lead wire because this can easily damage the electrode lead wire. The area of electrode contact with the skin should be dried to remove any electrode paste that is on the skin. The electrodes should also be cleansed to remove any remaining electrode paste from the center recessed area of the electrode contact surface.

V. HEART RATE STUDY

The phsyiologic effects of hidden ordinance detection on trained military dogs was studied by recording heart rate changes occcurring at the time of the detection response. It was believed that an increase in heart rate would be seen with the alert reaction of these dogs. This hypothesis was based on the concept that the dogs would undergo an excitation or fear response at the time of alerting which would elicit an increase in heart rate. This hypothesis was found to be untrue and, in fact, a decrease in heart rate was seen. In observing the dogs while working and during the alerting period, it was obvious that the response was not a fear reaction, but was simply an act of repeating a trained activity.

Two trained scout dogs were obtained from the Army Dog Command at Fort Benning, Georgia, to be used for collection of the heart rate data. These dogs were shipped to Fort Collins, Colorado, with their handlers on June 19, 1972. Upon arrival the dogs were housed in large runs and allowed to adjust to their new surroundings before being used for data collection. During this period of acclimatization, the handlers were familiarized with the surrounding country and sites were selected for ordinance detection and data collection.

The equipment utilized for recording heart rate included: a small magnetic tape recorder, the Phase II Saddle from the telemetry portion of the project, 3 Beckman silver-silver chloride paste on electrodes, a stop watch, a data log, and a single channel stripchart recorder.

The tape recorder employed for data collection was a commercially available unit designed specifically for recording the dynamic electrocardiograph. This unit, the electrocardiocorder, was designed for use as a heart rate monitor with human cardiac patients. This recorder has dimensions of 4" x 3" x 7", weighs about 3.5 lbs., and has a self-contained rechargable power supply with a battery power life of 8 to 10 hours. The magnetic tape is a standard high resolution recording tape on a 3.5" reel. The recording speed is slow and allows a recording time comparable to the battery

power life without changing tapes.

Operation of the cardiocorder is similar to any conventional reel to reel tape recorder. The tape is loaded in the unit and positioned to record following the last section of recorded data. The unit is controlled by two switches, a power on-off switch and a tape drive switch. The tape drive switch controls movement and postion of the tape with the power switch controlling the main power supply and recording electronics. To record data after the tape has been loaded into the recorder, the drive switch is moved to the on position, the recorder lid is closed, and the recorder is loaded into the saddle. The recording session is started by switching the lower switch to the on position. A time marker was incorporated into the cardiocorder utilizing a hand switch connected to the calibration jack of the recorder. A stop watch was employed during the recording procedure to correlate the tape position with time on a written log of the dogs' activities.

The tape recorder was carried by the dogs in the saddle designed and built specifically for this purpose. The saddle has the same basic construction as the Phase II Saddle from the telemetry system development portion of the project. A compartment for carrying the cardiocorder was designed, built, and fixed to the top of this saddle. The dogs tolerated the recording equipment quite well, but did not work out in front of the handler as far as they would without the saddle.

To prepare the dogs for data recording, a 3" x 3" area on each side of the chest, just behind the front limb was prepared for electrode placement. Three Beckman silver-silver chloride paste-on electrodes were used, an active electrode on each side of the chest and a neutral or gound electrode approximately 1.5" behind the active electrode on the right side of the chest. This electrode configuration placed the electrodes directly over the heart and produced a relatively artifact free ECG tracing with a large QRS complex.

After all three electrodes were fixed in place, the saddle was placed on the dog and the harness straps fastened. Prior to each data collection run the electro-

cardiocorder was prepared by checking the position of the tape to see that it had been run forward to the right place for recording the present data run. The drive capstan for the tape was then placed in the active position, the unit was closed, inserted into the carrier portion of the saddle, and the electrodes were plugged into the connector. When the recorder was turned on, the dog was ready for data collection.

The data collection runs were set-up to establish a resting heart rate before the start of the run. The cardiocorder unit was turned on and allowed to run for approximately 3 minutes to warm-up the unit and establish a resting heart rate. At the end of this time, the stop watch was started and the time marker switch was activated to indicate the beginning of data collection.

The ordinances were set-up far enough apart to allow a three to five minute working period between alerts. Following each alert the dog was brought back to the handler and another resting heart rate was established before roving out for the next quarry. Most of the data runs were set-up to be 10-20 minutes long and included 2 to 5 decoys or quarries. Following the last alert situation on a run, the dog was worked long enough to get a working heart rate. Another resting heart rate was then established to evaluate any changes in the base heart rate from the beginning of the run to the end of the run.

The log sheet was used for recording the dogs' activities and the time at which they occurred. Information recorded on the log included the time the dog first noticed a quarry, the time a definite alert occurred and the dog sat, the time the dog recalled to the handler, and the time the dog was moved out for the next ordinance. Any outside influences, such as birds or deer that distracted the dog were also recorded.

The procedures followed throughout the data collection period were to send handlers out in the morning to set-up detection courses. During the afternoon, the dogs were worked over the course while their heart rate was monitored and recorded. Each course was set-up with a different pattern of ordinances and different course locations were used each day. The ordinances used for this study included pungi pits,

trip wires, cashes and human decoys. The dogs were worked with a two man data collection team in an attempt to similate actual field conditions as much as possible.

After the data collection run was completed, the magnetic tape was returned to the lab for playback and paper stripchart printout. This was done with the electrocardiocharter, a unit designed to replay the magnetic tape and record the data on standard single channel ECG paper. This produced a tracing similar to the electrocardiograph used by doctors in diagnostic cardiology. The heart rate was determined from this stripchart printout.

The data was evaluated by determining the heart rate during resting periods, during working periods not associated with an alert response, and during periods immediately before, during and after alert responses. Changes in the heart rate with alert responses were analyzed statistically. The results from this analysis revealed a significant decrease in heart rate with the alert response for all data runs as a group. The data was then separated and each dog was analyzed individually for each type of quarry. All alert responses showed a significant decrease in heart rate over the working heart rate. The two dogs utilized for this study demonstrated considerable difference in their heart rate responses. For one dog (Figure 23), the trip wire alerts showed the greatest heart rate decrease, pungi pits were next but not significantly different from the trip wire decrease. The cashe alert showed a lesser decrease in heart rate which was significantly different from the trip wire, but not significantly different from the pungi pit or decoy alert. Human decoy alerts showed the least decrease in heart rate. This may have been related to an increase in heart rate seen with agitation of the dogs with some decoys following the alert. Decoy alerts without agitation showed a typical decrease in heart rate. With the second dog (Figure 24), the pungi pit alerts showed the greatest decrease in heart rate but were not significantly different from the decrease seen with trip wire alerts. A significant difference was seen between trip wire and pungi pit alerts as a group and the cashe and decoy alerts as a group, with the greatest decrease being seen with the trip

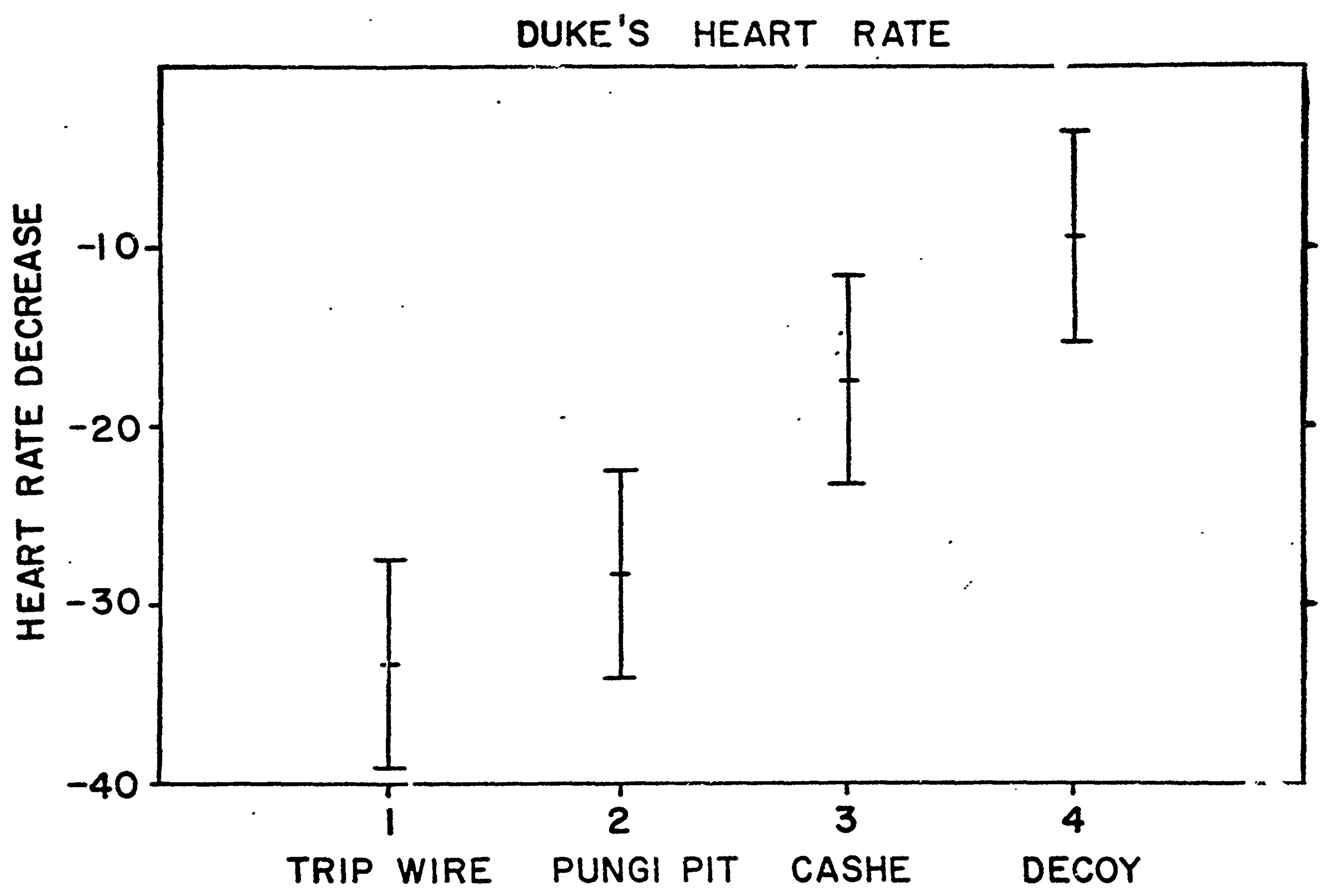


Figure 23 - Duke's Heart Rate

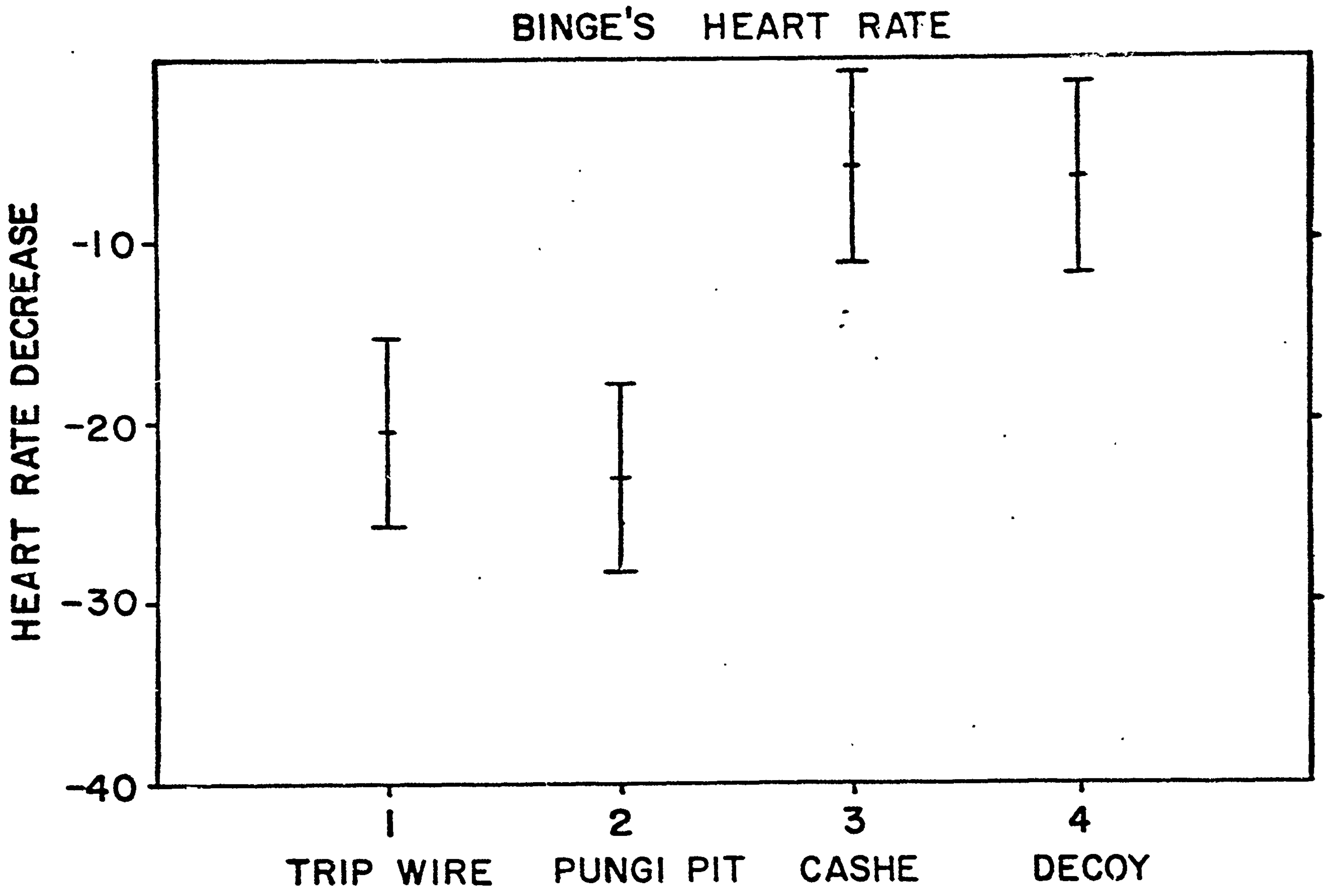


Figure 24 - Binge's Heart Rate

wire-pungi pit group.

Heart rate response studies in various species have shown that with increased sensory input situations a decrease in the heart rate occurs as opposed to situations of increased thought process where an increased heart rate occurs. The heart rate changes, in these studies, were not as great as those seen in this study. One factor that had an effect on the heart rates seen with these alerting responses was that of exercise. Exercise causes an increase in heart rate where a decrease in heart rate is normally seen with cessation of exercise. This could be closely correlated with the transistion from walking to the sitting position of the alert response. Insufficient control data was collected in this study to determine if there was a significant difference between the heart rate decrease of dogs simply changing from walking to a sitting situation and the heart rate change seen with dogs in an alert response situation. This area of study has been included in the protocol for "Physiologic Measurements in Military Dogs Specialized in Detection."

PHYSIOLOGIC MEASUREMENTS

Phase II

VI. INTRODUCTION

The extension of Contract DADA 17-72-C-2054 was for the study of "Physiologic Measurements in Military Dogs Specialized in Detection". Objectives considered the designing and developing of methods for measuring individual physiologic parameters in military dogs trained to detect insight and out-of-sight targets. The physiologic parameters included in the study were brain wave activity (EEG), heart rate, respiration rate, superficial and deep body temperature, eye movements and blood pressures.

The specific aims of the project were to design, develop and surgically implant electrodes, transducers and special sensors capable of measuring subtle physiologic changes in dogs trained in detection procedures; to collect and record the physiological data collected from the sensors; to evaluate, analyze and determine what physiologic parameters are affected during detection of a target; and to recommend possible uses of these findings to increase the potential of these detection dogs.

The research program involved a team effort to provide expertise and support in four different areas. The electronic package for collecting and decoding the data was designed and built by an electronic engineer with bioinstrumentation expertise; the surgical techniques were developed and perfected by veterinary surgeons; and the data analysis techniques were written and programmed by a computer team.

VII. PROJECT DEVELOPMENT

A. Sensor Philosophy and Development

The sensors required for use in this program varied greatly in design, type and utilization. Some were designed and fabricated at CSU while others were purchased from commercial suppliers.

For the measurement of blood pressure, a pressure transducer was utilized which converted the pressure of the blood within the arteries into an electrical signal for recording. The transducer utilized was a commercially-available model which was modified in design to better apply to the needs of this program. This unit was a Wheatstone bridge configuration strain gauge arterial pressure transducer with a pressure sensing range of 0 to 300 mmHg. When the unit was callibrated and then placed within the arterial system a very accurate measurment of blood pressure could be recorded under dynamic conditions with a minimum of artifact signal.

Temperature, both superficial and deep body, was measured with thermistors that varied resistance to temperature change and converted that resistance change to electrical current differential. The thermistors used were commercially-available glass-coated resistors with a temperature capability within 80° - 120° F. A warm water bath callibration system was utilized to produce a graph of temperature versus voltage of the recorded signal. These thermistors were highly accurate and free of external noise.

The electrode sensors for detecting EEG were designed and built specifically for use on this project by our own electronic engineering team. The major problem with recording dynamic EEG is the low voltage of the signal generated compared to the high level of contaminating signals (noise). To minimize the unwanted signals the sensors were placed directly on the surface of the brain (dura mater) through holes drilled through the boney cranium. Shielded wiring was used for the leads to insulate against muscle potentials generated in the cranial area. The EEG electrodes were made from a cylinder of Orthopedic-grade stainless steel (SMO 18-8, type 316)

about 2mm in diamenter and 2mm long. A very small hole was drilled into one end of each cylinder for the attachment of the lead wires. These electrodes were housed in small Teflon cups with a flat base. Only the tips of the electrodes were left protruding from the top of these cups. A threaded Kynar holder for each electrode assembly was designed to screw into the cranial bone of the skull to receive the electrode assemblies as a snap tight fit. When the units were implanted in the in the skull, the tips of the electrodes were held in direct contact with the dura mater covering the brain and were fixed tightly, thus minimizing movement artifacts. A special set of surgical instruments were developed to implant the EEG electrode assemblies which consisted of a drill with a depth adjustment, a special tap and a wrench for inserting and tightening the threaded electrode holder.

Testing the electrodes revealed significant levels of artifact signal when the dogs were undergoing vigorous activity; however, the noise levels were within workable limits. Under resting conditions and light activity the signal to noise levels were excellent.

Eye movement sensors were designed and fabricated for the project by the electrical engineer. The basic principal of these sensors was similar to the EEG electrodes and the same shielded wiring was used for the leads. The electrode itself was made from Orthopedic grade stainless steel as a washer with an external diameter of 1 cm, an internal diameter of 5 mm and a thickness of 1 mm. A small hole was drilled in the side of the washer for coupling of the lead wire. The wire was crimped into the washer for positive fixation. The coupling joint was then potted with dental acrylic to increase strength and to protect against corrosion. This electrode was then surgically affixed to the bone of the orbit with a nylon screw. Another set of special instruments was needed for the insertion of these electrodes. The electrodes worked very well with a good signal to noise ratio under most conditions and were much more easily implanted and removed than previously utilized designs.

Respiratory rate was monitored by external transducer designed and built as a Wheatstone bridge strain gauge placed on the cross piece of an "S" shaped aluminum frame. This assembly was then attached to a harness which was fitted around the chest of the dog under light tension. This resulted in a change in the stress on the strain gauge with inspiration and expiration and thus a change in the electrical signal generated. The signal produced was sufficient if the tension on the harness was adjusted properly to give an accurate recording of respiration rate.

B. SURGICAL TECHNIQUE DEVELOPMENT

The monitoring techniques utilized in this research contract required the surgical implantation of sensing devices to achieve sufficient signal magnitude with consistency and without artifacts. The only parameter for which implantation was not necessary was respiration which was recorded through a strain gauge transducer placed externally around the chest. The choice of surgical techniques considered for this project was influenced to some degree by the requirement that all the trained dogs to be implanted were to be returned to the Army in functional condition following the experiments. Because of this requirement surgical techniques had to be developed not only for implantation of sensors but for the eventual removal of these sensors without impairment of the dogs. Consequently many of the sensors had to be modified to permit easy and safe removal.

Implantation of the blood pressure sensing device was accomplished by thoracotomy and inserting a pressure transducer into the posterior thoracic aorta. The chest was opened with a routine left lateral intercostal thoracotomy incision and the aorta was isolated with non crushing vascular clamps and opened with a small incision. A purse-string suture was placed around the aortic incision and the transducer was inserted into the aorta. The purse-string suture was tied to seal the aortic wall and the vascular clamps removed. Any hemorrhage around the insert area was controlled with simple interrupted sutures. The lead wire from the transducer

was brought out of the chest at the dorsal end of the incision and the chest was closed in routine fashion.

Removal of the transducer was accomplished through a parallel incision of the chest area. With the chest opened, the transducer and lead wire were disected free of all surrounding fibrous tissue and the segment of aorta containing the transducer was isolated with noncrushing vascular clamps. The transducer was removed and the defect in the aortic wall was repaired with a simple continuous suture. This was the most difficult of the procedures and required a week's post-surgical convalescence.

Implantation of the EEG electrodes required exposure of the dorsal aspect of the cranium for trephing the skull in preparation for anchoring the electrodes into the bone. The cranium was exposed by incising the skin and soft tissues in the dorsal midline and elevating all soft tissues from the bone to give sufficient exposure for the implants. Five trephine holes were then drilled in the bone, two in frontal region, two in the occipital region and one vertex. The holes were tapped to receive the threaded insets and the electrode bases were screwed in and tightened. The electrodes were then snapped into these base components. The lead wires were fixed with suture to the skull to prevent any pull-stress on the electrodes and the wires were passed subcutaneously to a point on the dorsal midline at the caudal end of the neck.

Removal of the EEG electrodes required the same approach as for their implantation. The electrodes were snapped out of their bases and the lead wires were cut off to facilitate the removal of the lead wires without causing undue tissue damage. The electrode bases were unscrewed and the incision closed in a routine fashion. The recovery period following surgery in these dogs was quite rapid and all dogs were ready for use within one or two days post-surgery. Following removal of the electrodes the skeletal defects created by the drill holes were completely healed within 12 weeks.

The eye movement electrodes were implanted with a technique similar to that used for the EEG electrodes. Four Electrodes were placed around the orbit through a series

of short incisions down to and exposing the bone. Radial incisions were made lateral to each eye, and above and below one eye to allow placement of electrodes for measuring both horizontal and vertical eye movements. The bone was exposed at each of these incision sites and a small hole was drilled and threaded for each electrode. The stainless steel electrode was then fixed in place with a plastic screw.

Removal of these electrodes was accomplished by surgical exposure of each electrode and lead wire fixation point on top of the head. The electrode fixation screws were removed freeing the electrodes, and the lead wires were cut and removed. The implantation and removal of the eye movement electrodes often resulted in considerable swelling around the eyes which required several days to return to normal. In most cases the dogs were ready for monitoring within one week.

Implantation of the temperature sensors was accomplished at the same time of implanting the blood pressure transducer in the chest and involved fixation of the deep thermistor within the chest. The lead wire was brought through the chest incision to a subcutaneous pocket on the dorsal aspect on the neck to exit from the skin. Removal of the thermistors required dissection of the lead wires from the surrounding tissues at the time the blood pressure transducer was removed.

C. ELECTRONICS DEVELOPMENT

An eight channel data collection system was designed and built. This unit consisted of three major components: the data acquisition system, tape reader and power supply that were assembled into a back-pack saddle to be carried by the dogs.

The core of the unit was the data acquisition system which consisted of eight-channel inputs to in vidual amplifiers. Each amplifier was designed to be easily removed and replaced thus making it possible to vary the capability of the package quickly, giving a great diversity of data recording combinations. For example, the full eight channels of EEG could be recorded simultaneously, or blood pressure, temperature and respiration rate could be recorded together, or these parameters

could be combined with eye movements or with up to four more channels of EEG.

Behind the individual channel amplifiers was a multiplexing unit that combined all the eight channels into a single signal for recording. This unit was designed to accomodate from one to eight channels to coincide with the number of channels of data being recorded at that time. This was set up with an automatic sequential switching system which progresses from one channel to the next until a coding or final channel is reached. The process is then repeated starting with channel one. Single channels could also be selected and recorded continously.

For single channel recording a miniature commercial cassette tape deck of high quality was purchased. The resolution of the unit was not sufficient so the audio-recording head was replaced with a digital head and the tape speed was increased to the maximum possible without producing distortion. These modifications produced an acceptable level of resolution.

The third portion of the system was a battery power source for operating the data acquisition system. The size of the power supply, and the operating time of the system, was directly related to the weight carrying capability of the dogs.

The three components were packaged on a fiberglass saddle with the data acquisition system on top, the tape recorder on one side, and the battery powerpack on the other. This resulted in a well-balanced and rugged unit with a total weight of about 4 kg.

This complete monitoring system was tested extensively under field conditions utilizing all parameter and conbinations of parameters required to monitor physiologic responses that might be exhibited by detection dogs sensing a "target". Many changes and considerable debugging was required before a stable and dependable system was attained.

D. DATA ANALYSIS METHODS DEVELOPMENT

To utilize the recorded multiplexed data, separation back into the original

channels and decoding was required. A system for accomplishing this was designed, built and tested. This unit contained the same basic components as the multiplexing system, working in reverse order. The multiplexed data from the cassette tape was played back through the tape deck into the demultiplexer which separated and decoded it into its original signal.

From this unit the output signals could be displayed on a oscilloscope, printed out on a stripchart or recorded on multichannel magnetic tape for use with a computer.

The multichannel magnetic tape was taken to the Computer Center where the data was converted into digital form and retaped. The initial computer analysis of all forms of the data was a direct printout of the analog data to double check the accuracy of the recording and digitizing methods. Following this each parameter was analyzed individually.

The analysis of the EEG signals involved a fast Fourier transform of the signal frequency and cross-correlation spectrum analysis of the FFT of different channels This resulted in a continous graphic display of the frequency of the EEG over the entire period of data collection. The cross correlation analysis then produced a display of the similarity of frequencies between different areas of the brain.

Blood pressure signals were anylyzed by computing the maximum, minimum and mean pressures. These results were then printed simultaneously on the same graph. The entire period of the data collection could be analyzed and printed as a continuous graph. In addition to the pressure data the program was capable of reading heart rate from the pressure wave and continuously graphing of this value. The blood pressure program was applied to the respiration rate signal and printed out as a simple graph of rate.

The analysis of the temperature data did not require the computer; however, this data was handled by the same methods to allow manipulation of the time scale of the printout and to produce a constant format to facilitate comparison of different parameter.

The eye movement signals were not suitable for computer analysis and were evaluated from the analog signal. The rate and magnitude of the movements were observed as well as the patterns of the movements.

The system of computer programs was organized to allow a greater degree of versitility without modification of the component parts. One use of this versitility was the application of the respiration rate and blood pressure signals of the fast Fourier analysis program to look for changes occurring at the time of the alerts.

The various parameters could also be compared through the cross correlation spectrum analysis which might detect comparative changes in the different parameters that were not detectable by other means.

VIII. CONCLUSIONS

The contract obligations of Colorado State University were to prepare the equipment and techniques for studing of physiologic data obtained from trained Army dogs during alerts on hidden targets. All the necessary electronic recording equipment, physiologic sensors, surgical techniques and data analysis methods have been developed, tested and perfected to accomplish these ends. The sensors were implanted in experimental untrained dogs and were checked out individually as well as in combination as the system was designed. The system was modified until all physiologic signals could be collected with reliability and within acceptable tolerances.

The last portion of this contract could not be performed since the United States Army elected not to furnish the trained military dogs and handlers for the final test periods. Consequently, there could be no data collected or analyzed. Performance on this contract, as far as Colorado State University is concerned, did advance the state of the art in bioinstrumentation. A unique data system was designed, developed and successfully tested on living animals subjects. This data acquisition system and knowledge derived from its development may be used wherever dynamic physiologic parameters must be monitored.

IX. APPENDIX

A. SUMMARY

Appended to this final report is an operating instructions summary section giving the specifications of the data acquisition pack, theory of operation of the system, and data reduction techniques.

Also appended is the data reduction techniques with photos, charts, and diagrams of the physiologic signal conditions, and finally attached is a User Document for the Dog Physiological Data Graphic Display System.

SUMMARY

TABLE OF CONTENTS

I. INTRODUCTION

The ten-channel Data Acquisition System was developed out of a need to study physiological behavior in dogs trained in detection. The research area is a demanding one, requiring the continuous recording of physiological data from dogs who are free-ranging and in the process of detecting a target. The technique of tape recording this data was pursued to significantly reduce the in-field hardware as required in FM techniques. The system consists of two (2) elements, that of the data acquisition pack and the data processor.

The data acquisition pack is made up of three units mounted on a saddle which is worn by the dog during monitoring. These units are:

1) physiological signal conditioning, multiplexer and encoder instrument:

2) battery case containing four rechargeable 6VDC nickel cadmium batteries; and

3) cassette tape recorder case containing the recorder (Figure 1).

The data processor is an instrument which decodes the serial data played back from the cassette tape recorder and reconstructs the recorded physiological analog data. Analog data is outputted on a 14-channel IRIG tape recorder for future analysis or the data can be recorded on strip charts for quick-look information (Figure 2).

II. OPERATING INSTRUCTIONS

Operation of the system from the recording of data to data playback has been kept to a minimum degree of difficulty. Having determined the physiological function or functions to be recorded, select and install the proper physiological signal conditioning card (Figure 3). Select the data recording mode desired using

random access switches for single-channel operation or the channel scan switches for multiple-channel operation (Figure 4). Turn the power switch to the "ON" position and remove the recorder control plug (Figure 1). With the recorder running, use the random access switch to record reference and syncronization information on tape and then return the switches to the proper operating position. The data acquisition pack is now recording data. After completing data recording run, insert the recorder control plug and turn the power switch to "OFF". Remove the recorder from the case and rewind the tape to the starting position. The tape is now ready for processing.

In preparing for data playback, select the desired output recording method: analog tape or strip charts. Connect these units to the data processor. Select the proper data playback mode by use of the random access switches (Figure 2). Turn the processor power switch to the "ON" position. Connect the cassette recorder to the processor signal in connector and start the recorder. Adjust the signal level control until a steady flashing of the signal level LED is observed. Having obtained a steady flashing, the data and syncronization LED's should be lit. Now that the processor is functioning normally, analog data is being outputted to the recording devices for storage or quick-look analysis.

III. SYSTEM SPECIFICATION

Data Acquisition Pack

The data acquisition pack can signal condition, digitize and record up to eight (8) physiological measurements simultaneously. Each channel is sampled, a minimum of 250 samples per second per channel, providing recording bandwidth of DC to 50HZ. All physiological measurements are signal conditioned to provide a bipolar output voltage range of one (1) volt peak to peak. Two additional channels (9 and 10) are utilized to provide a reference voltage and syncronization information. Power is supplied by four (4) six volt (6V) nickel cadmium rechargeable batteries. Tape head output is 3MV P-P during playback.

Data Processor

Input signal level: .5V to 2V peak processing rate is 2.5KHZ to 50KHZ. Analog channel output level: 1:1 or any ratio to a maximum output of 10V P-P. Power equipment: 117VAC @ .12A

Digital Computer

Data Processor can be equipped with a formatter providing computer compatible digital tapes.

IV. THEORY OF OPERATION

Data Acquisition Pack

The data acquisition pack is designed to signal condition, digitize and record eight (8) physiological measurements at a sample rate of not less than 250 samples per second. Basic block functions of the pack are signal conditioning, analog to digital conversion, multiplexer and control circuits, encoder, voltage regulators and a modified cassette tape recorder (Figure 1). Unregulated power is supplied by four (4) 6V rechargeable nickel cadmium batteries.

The data channels, along with the reference and syncronization channels, are scanned by a ten-channel multiplexer and sample and hold circuit. Sequentially, each channel voltage is applied to the analog to digital converter. A unique aspect of this ADC is that the conversion time is a function of the input voltage. A positive one (1) volt is the minimum time, and the syncronization voltage is the maximum time required for conversion. The ADC produces a clocking pulse which is applied to the multiplex sequence circuit. This clocking pulse controls the entire timing operation of the unit. The converted data pulses are applied to an encoder circuit which provides the drive for the tape recorder head.

Variations of the multiplex sequencer operation are provided by use of the random access switches. With the RA switch in the "ON" position, individual channels can be selected by use of the four (4) BCD switches. In this mode only the selected channel is recorded.

The voltage regulator circuit converts the unregulated $\pm$ 12V DC battery voltage to a well-regulated $\pm$ 10.5V DC. An additional +5V regulator supplies the bias voltage for the TTL logic circuits.

V. THEORY OF OPERATION

Data Processor

The Data Processor's function is to decode the serial data played back from the cassette tape and reconstruct the ten parallel channels of analog information. The Data Processor's front panel consists of processor controls and signal input and output connectors (Figure 2).

Signal Level

Signal level is adjusted by use of the signal level pot. This pot controls the input comparator voltage. A mid-span setting will supply a 1V detection level which is correct for normal operation. Proper setting of this pot will cause the signal level light to flash at approximately one flash per second when an input signal is present.

Audio Level

Audio output level is adjusted by means of the audio span control pot.

Random Access

Random access switches allow for the processing of single channel continuously recorded data.

Data Light

The green data light (LED) must be illuminated continuously as an indication that data is being read correctly.

Syncronization Detector LED

The syncronization light will produce a steady level of light when the processor is decoding data correctly. Driver information for the syncronization light is derived from comparing the ADC output with an internally-generated reference

voltage. When a comparison is made, a mono-stable multivibrator produces an output pulse of adjustable width to the syncronization detector LED driver circuit. A driver pulse is produced for every syncronization detection.

Signal Input

Signal input connector provides access to the processor. Input signal amplitude can range from ± .5V to ± 5V P-P.

Syncronization Output

The processor decoded syncronization pulse is presented to the output connector for scope monitoring.

D/A Output

This signal is the analog converted voltage from the ADC. The signal (see Figure 2) can be used for basic analysis of processor operation.

Data Output

This output is a pulse (see Figure 6-2) which is produced by reconstruction of the input pulse. The pulse occurs where the input signal level equals the comparator voltage set by the signal level pot.

Proper operation of the data processor ADC and signal detector circuits can be determined by observation of the syncronization and D/A outputs with a dual trace oscilloscope (Figure 6-3,7).

Analog Channel Outputs

The analog output connectors are interface points for monitoring or recording the digital data processed by the data processor. The serial digital data is converted to analog data by the DAC and multiplexed to the correct channel sample and hold amplifier card. These analog channel outputs can be adjusted (calibrated) for an output range to ± 5V. Bandwidth of the amplifiers are set for DC to 45 HZ.

Power Supply

The processor power supply provides five regulated DC voltages: +12, -12, -20, -Refence- and +5. All voltages are adjustable except the +5 and -20.

These voltages provide the necessary bias for the processor operation. The power supply and circuits are protected by a .1A resetable circuit breaker located at the back of the processor. Input power requirements for the processor are 117VAC at 050-60HZ at .1A.

VI. PHYSIOLOGICAL SIGNAL CONDITIONING CARDS

There are four (4) types of signal conditioning cards used to condition the six (6) physiological measurements. These cards are:

1) EEG, EOG and ECG (Figure 7);
2) Respiration rate (Figure 8);
3) Temperature (Figure 9);
4) Blood pressure (Figure 10)

EEC, EOG and ECG signals are picked up by implanted electrodes and amplified from microvolt and millivolt levels to an average of one volt by a high gain AC coupled differential amplifier. This amplifier has three (3) adjustments:

1) Common mode;
2) Gain;
3) DC offset

Bandwidth of the amplifier has been set for -3db, 1HZ to 50HZ.

Respiration rate is measured as a millivolt output from a two-arm strain gauge arrangement attached to a small beam in a strap which is placed around the rib cage. The signal dimensions are in millivolts per pound of force (mv/#). The millivolt signal is amplified by a high-gain bright amplifier having a bandpass of 1HZ to 50HZ. This card has one (1) adjustment for Gain. The resulting output is volts per millivolts per pound of force (V/mv/#).

Temperature is measured with a thermistor with dimensions of change in resistance as a function of change in temperature (ohms/degree). The thermistor is placed in a single-arm bridge arrangement. The bridge output voltage is amplified

and filtered with a low-pass filter (DC to 30HZ).

There are three (3) adjustments:

1) Bridge balance;

2) Common mode;

3) Gain

Blood pressure is measured by a Konigsberg 1017 pressure transducer implanted in the aorta. The transducer is a four (4) arm bridge type with output dimensions of change in resistance as a function of pressure (ohms/mmHg). The millivolt output from the bridge is amplified by a high gain differential amplifier and filtered by a low-pass filter (DC to 30HZ).

There are two (2) adjustments:

1) Bridge balance;

2) Gain

APPENDIX

DATA REDUCTION TECHNIQUES

I. Data transfer from cassette to analog tape

II. Digitizing the analog tape (seven-track IBM ½" tape)

A. Packing density - 800 bits per inch

B. Sample rate - 250 bits per second

C. Time code - IRIG B can be used

III. Computer programs for analysis (Fortran IV, CDC 6400)

A. Raw data - plots raw data voltage/time (seconds)

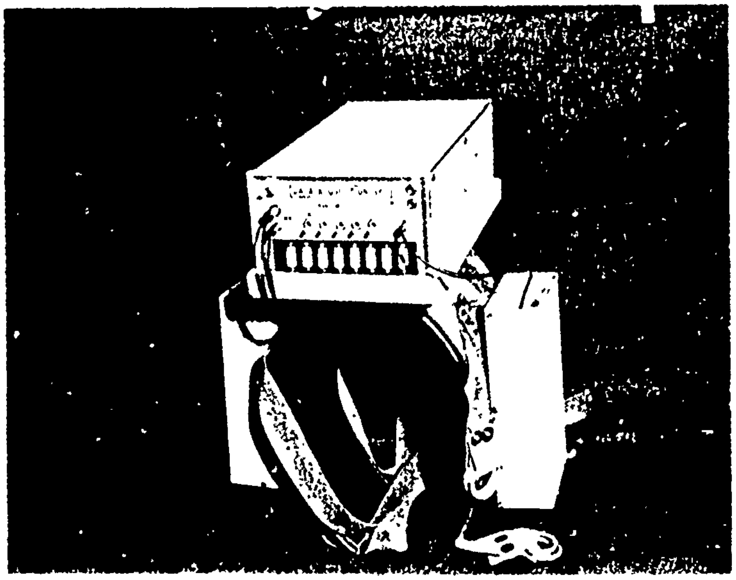
B. Ongoing frequency spectra - plots power/frequency

C. Cross correlation - plots correlation function

D. Cross power - plots cross power

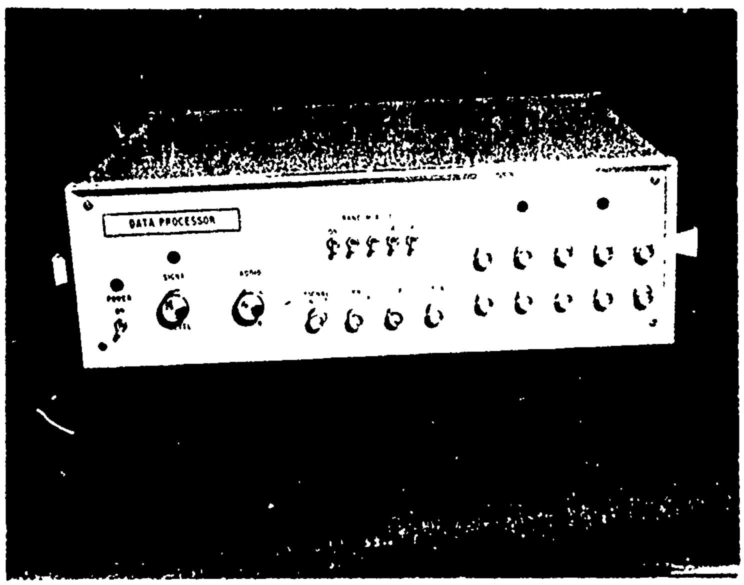
E. Blood pressure/respiration rate - plots systolic, mean and diastolic pressure mmHg/time; computes and plots heart rate bpm/time; respiration ipm/time

F. Temperature - plots temperature/time



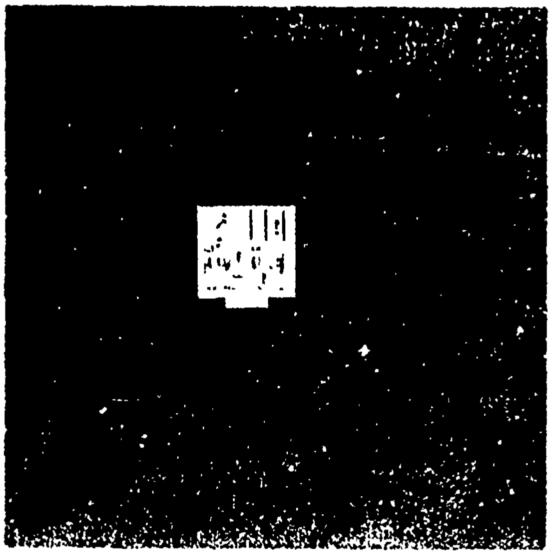
DATA ACQUISITION PACK

Figure 1



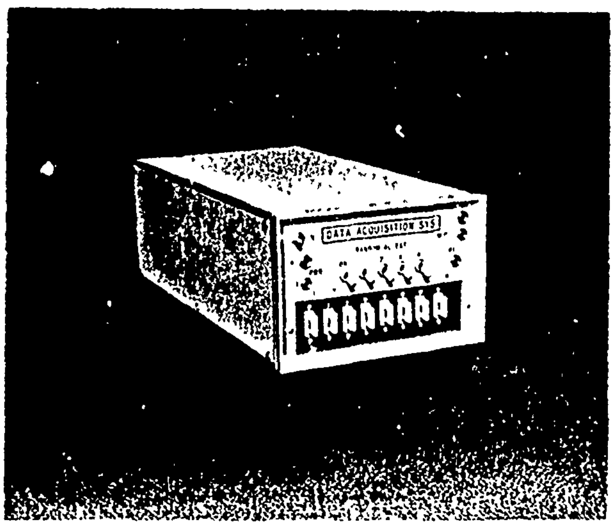
DATA PROCESSOR

Figure 2



SIGNAL CONDITIONING CARD

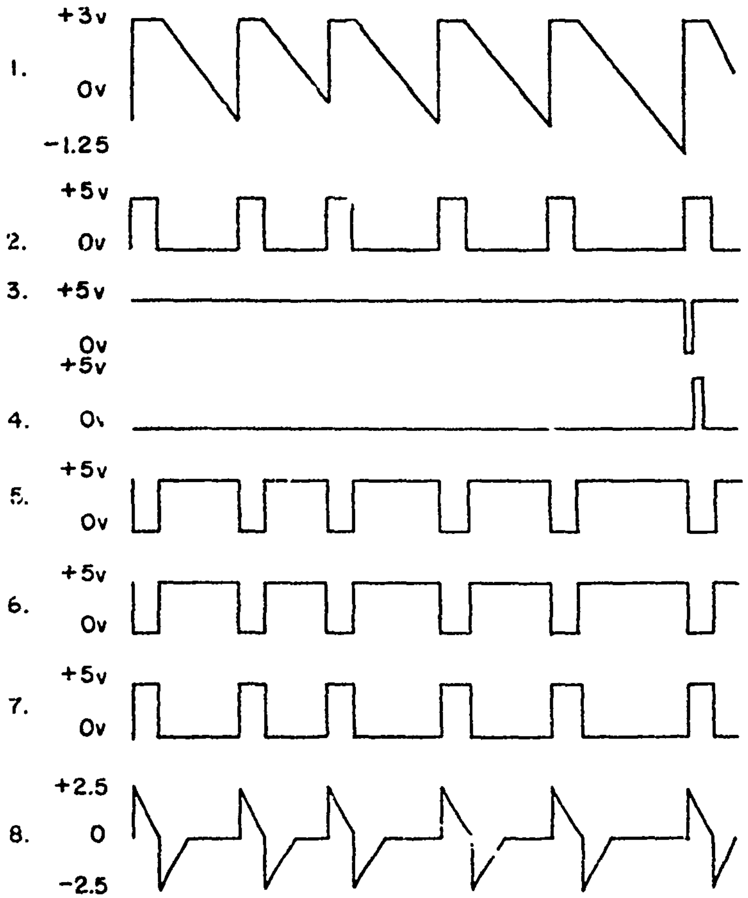
Figure 3



DATA ACQUISITION UNIT

Figure 4

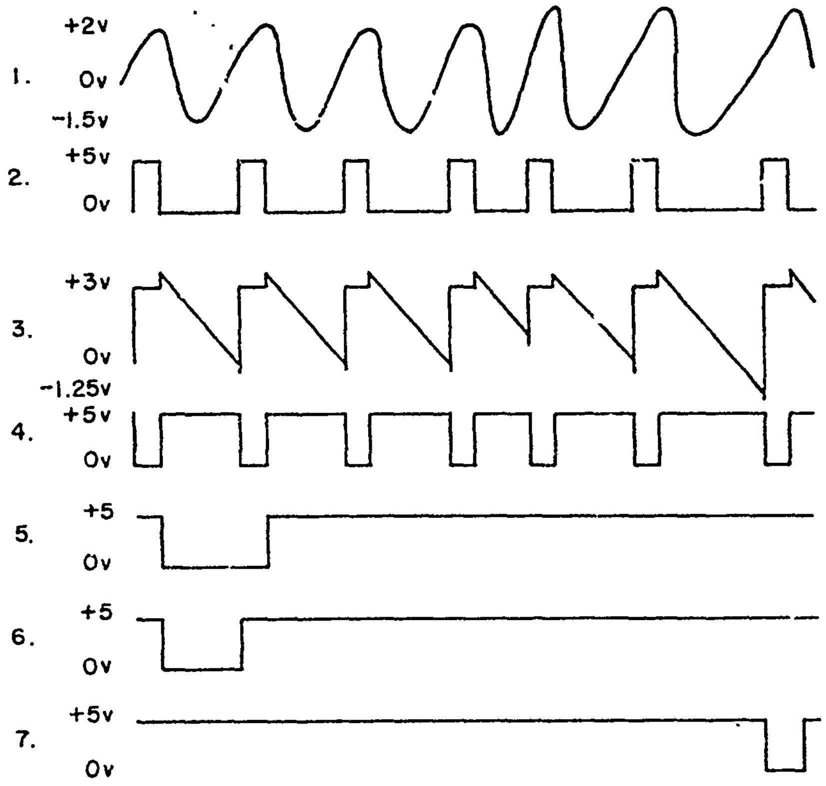
DATA ACQUISITION SYSTEM TIMING DIAGRAM



1. A/D CONVERSION RAMP
2. A/D GATE PULSE
3. REFERENCE DETECTOR PULSE
4. "O" CHANNEL SET PULSE
5. CHANNEL ADVANCE PULSE
6. ENCODER DRIVE PULSE
7. ENCODER OUTPUT PULSE (NO LOAD)
8. ENCODER OUTPUT PULSE (RECORDER LOAD)

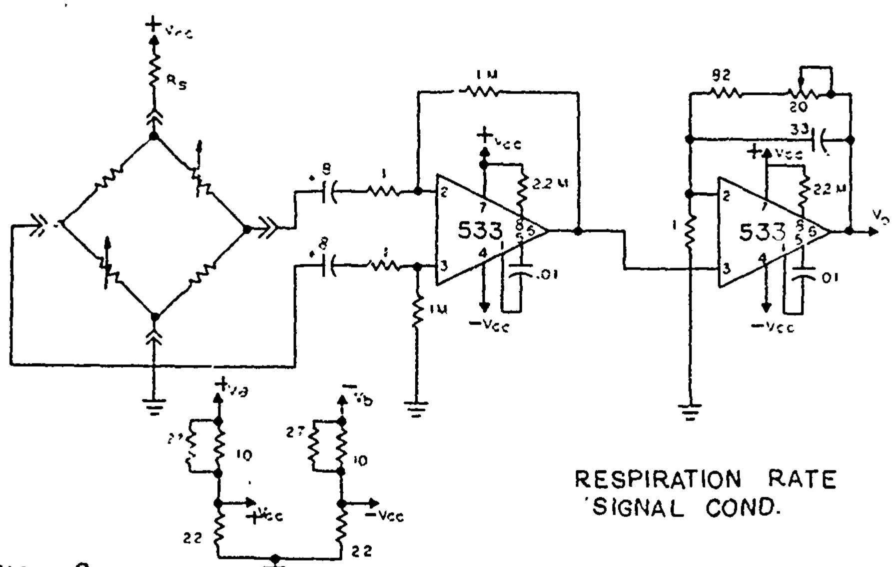
FIG. 5

DATA PROCESSOR TIMING DIAGRAM



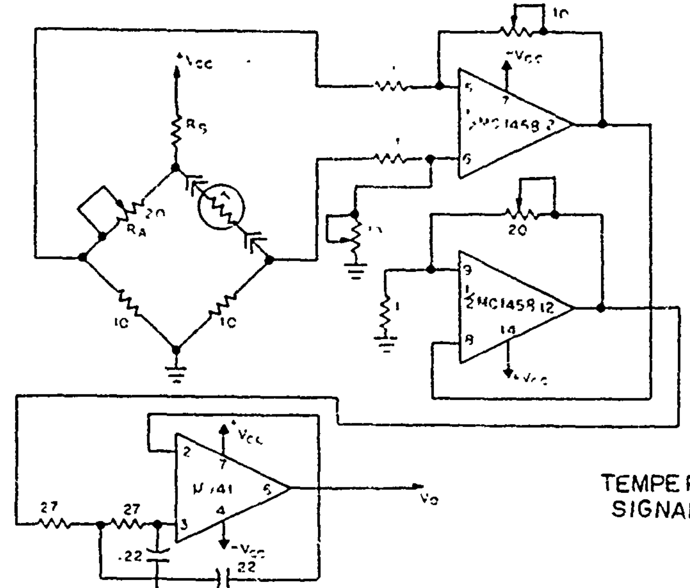
1. ANALOG INPUT TO DECODING COMPARATOR
2. DECODING COMPARATOR OUTPUT PULSE
3. DIGITAL TO ANALOG CONVERSION RAMP
4. CHANNEL ADVANCE PULSE
5. SAMPLE & HOLD DECODING PULSE (R)
6. SAMPLE & HOLD DECODING PULSE (S)
7. "O" CHANNEL SET PULSE

FIG. 6



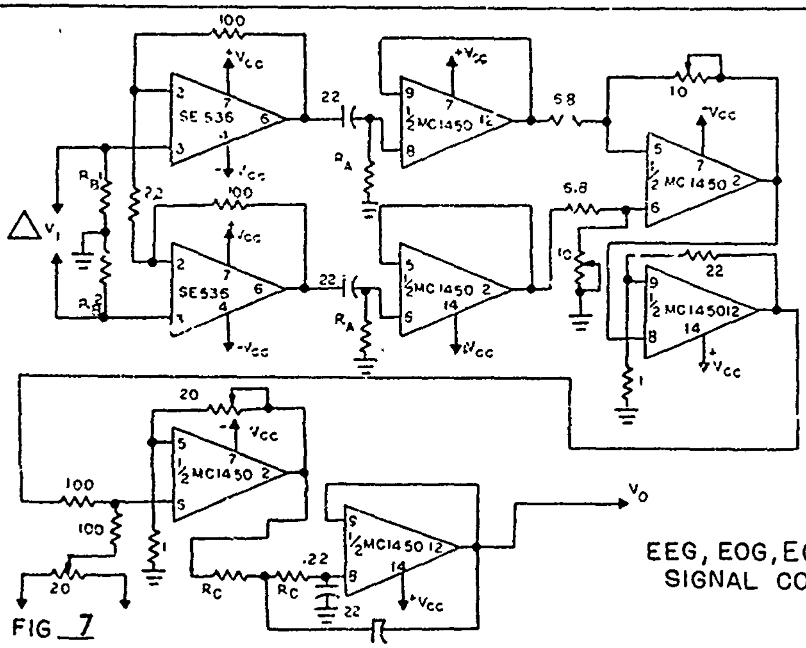
RESPIRATION RATE
SIGNAL COND.

FIG. 8



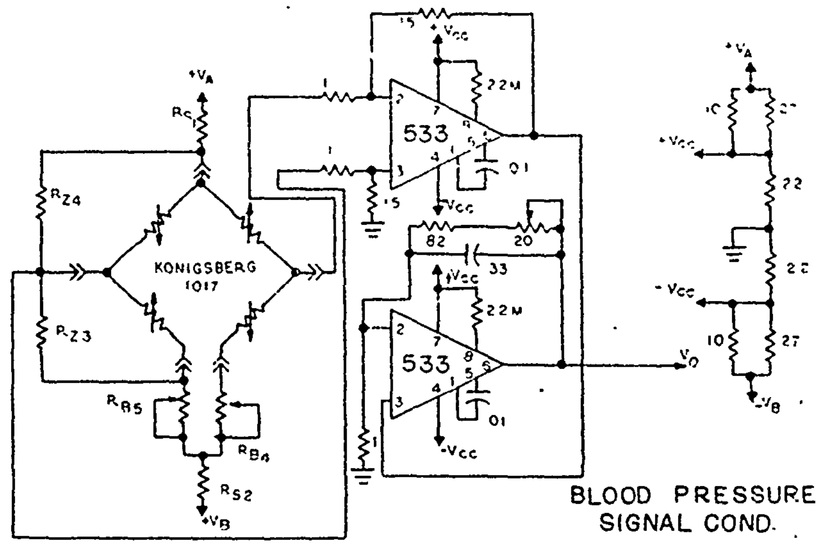
TEMPERATURE
SIGNAL COND

FIG 9



EEG, EOG, ECG
SIGNAL COND.

FIG 7



BLOOD PRESSURE
SIGNAL COND.

FIG. 10

DATA PROCESSOR
BLOCK DIAGRAM

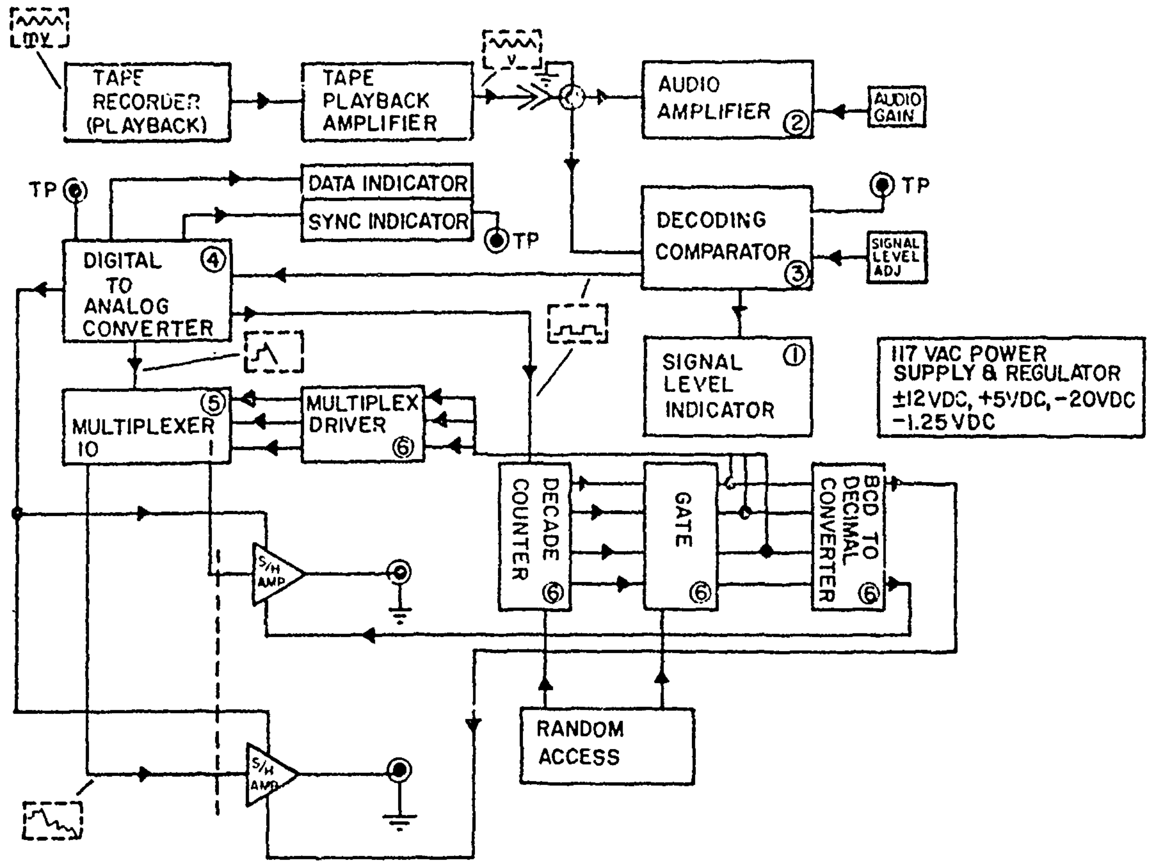


FIG. 12

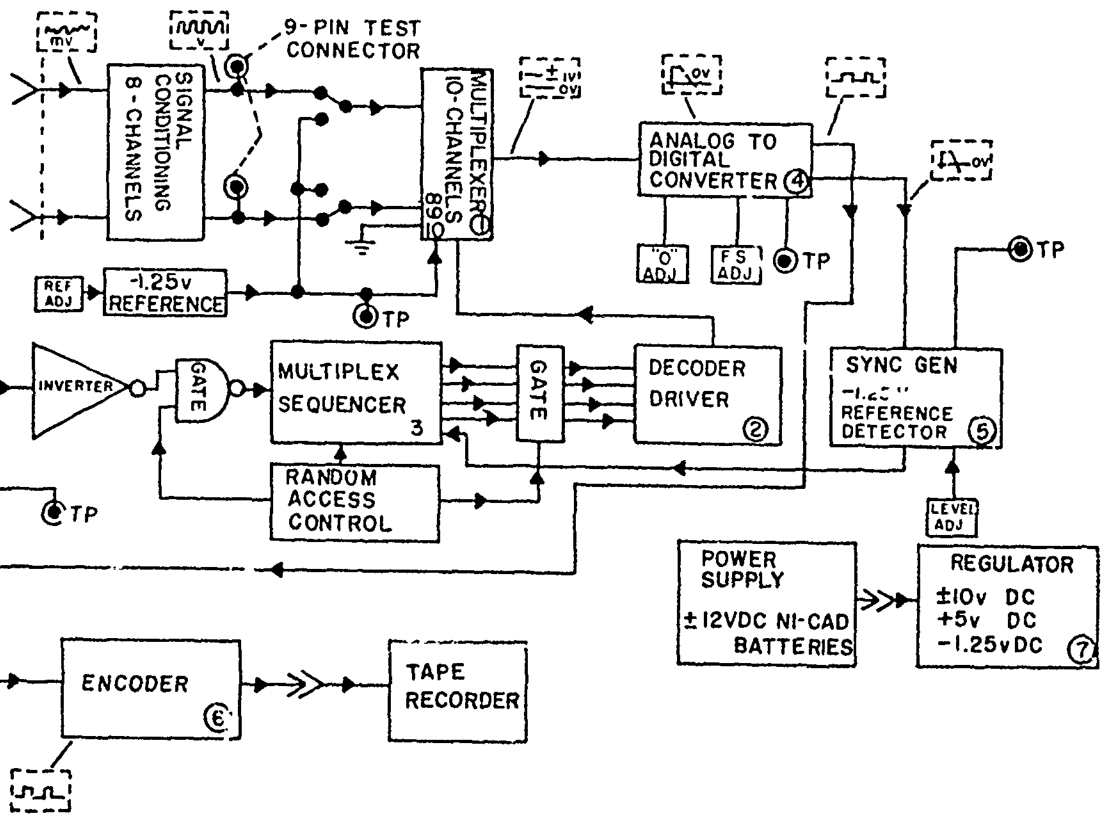
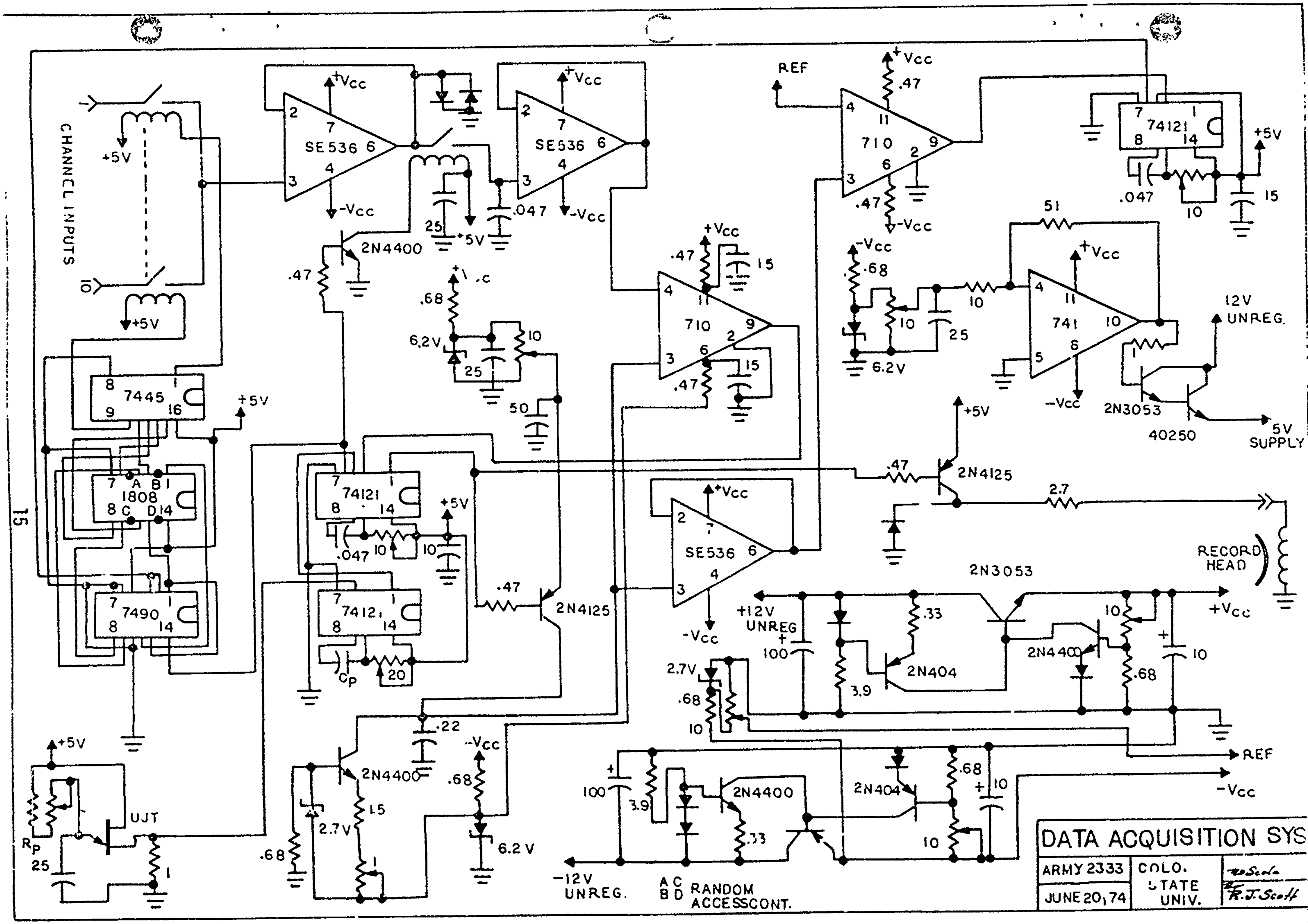
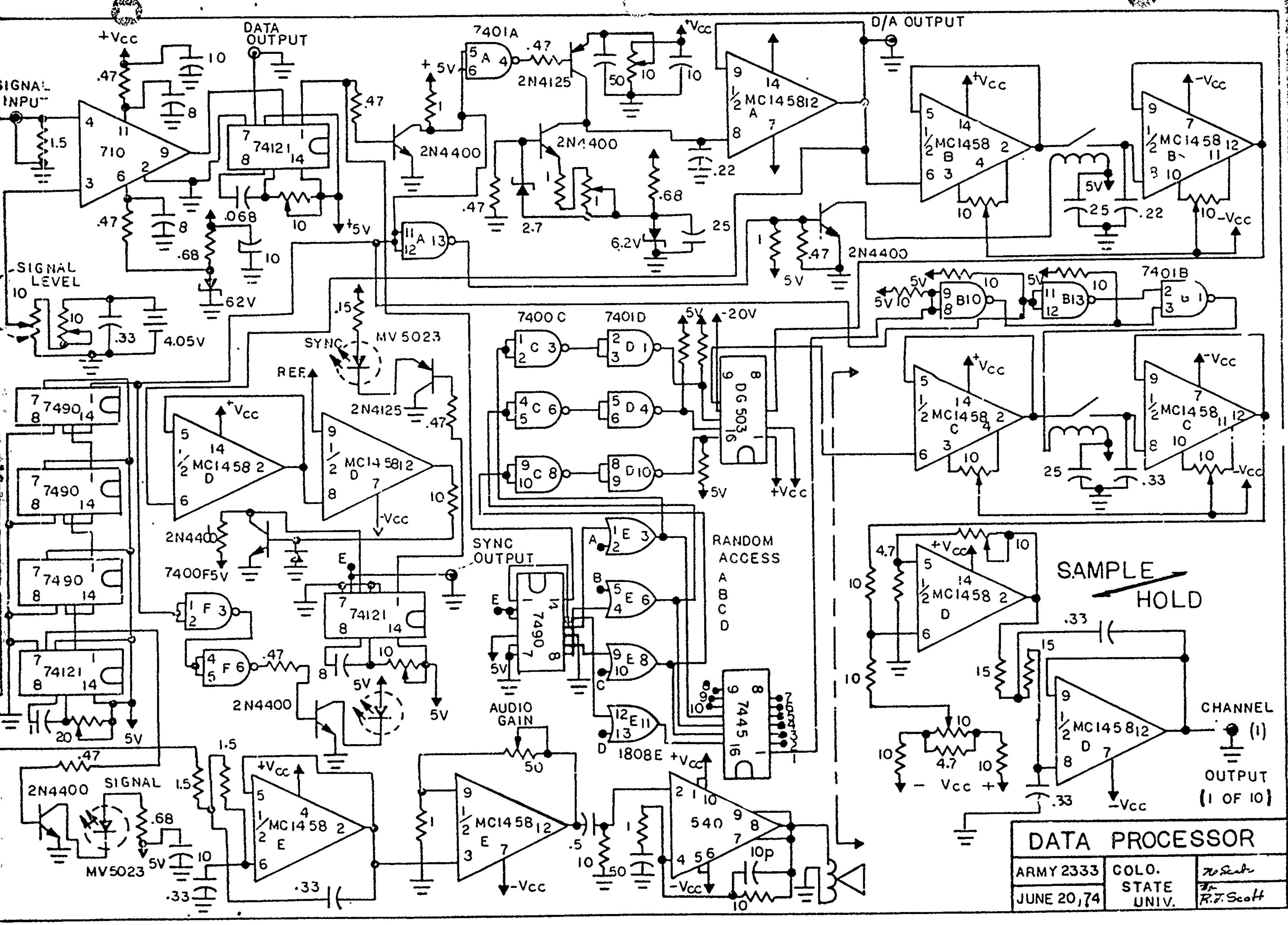


FIG. 11

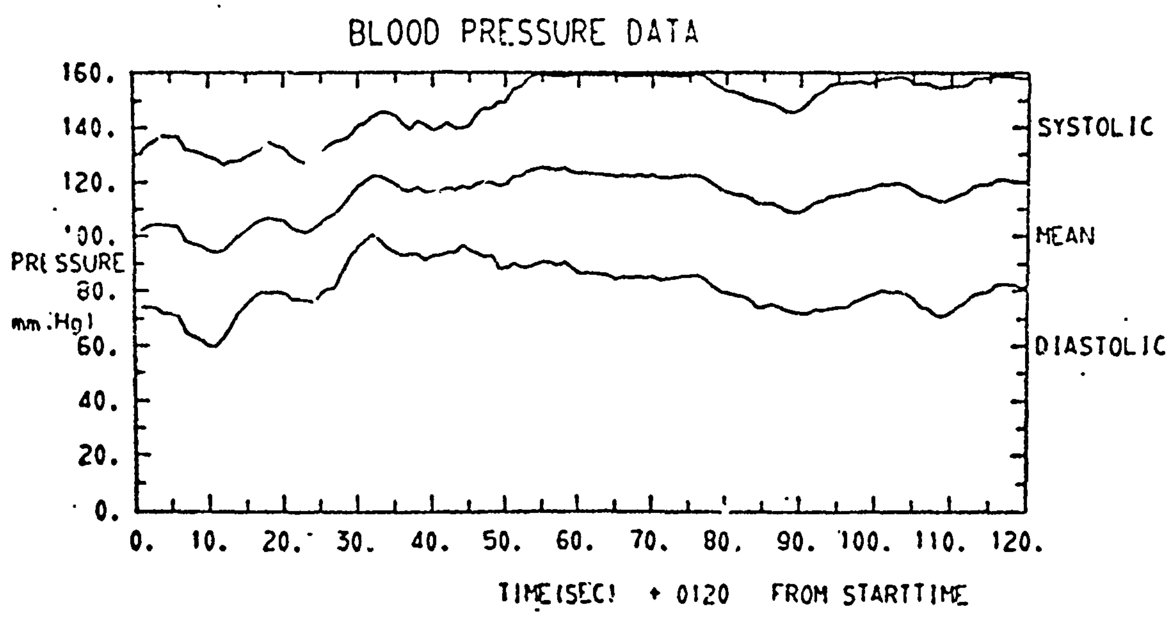
DATA ACQUISITION SYSTEM
BLOCK DIAGRAM



CHANNEL INPUTS
SE536
710
741
74121
7445
1808
7490
2N4400
2N4125
2N3053
2N404
40250
UJT
RECORD HEAD
12V UNREG.
5V SUPPLY
+12V UNREG
-12V UNREG.
AC BD RANDOM ACCESSCONT.
REF
DATA ACQUISITION SYS
ARMY 2333
JUNE 20, 74
COLO. STATE UNIV.
R.J. Scott


DATA PROCESSOR
ARMY 2333
JUNE 20,74
COLO. STATE UNIV.
R.T. Scott
SIGNAL INPUT
DATA OUTPUT
D/A OUTPUT
SIGNAL LEVEL
SYNC OUTPUT
RANDOM ACCESS
A B C D
AUDIO GAIN
SAMPLE
HOLD
CHANNEL (1)
OUTPUT (1 OF 10)

USER DOCUMENTATION
FOR THE
DOG PHYSIOLOGICAL DATA
GRAPHIC DISPLAY SYSTEM



Report Produced
12/10/74

USER SERVICES GROUP
UNIVERSITY COMPUTER CENTER
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
80521

USER DOCUMENTATION
FOR
DOG PHYSIOLOGICAL DATA
GRAPHIC DISPLAY SYSTEM

The Dog Physiological Data Graphic Display System is a series of programs created by Greg Bourque. User Services Group of the University Computer Center at Colorado State University. These programs are designed to facilitate analysis of multichannel data acquired originally on analog tape. These tapes are then converted to 7-track digital tapes by the REDCOR analog to digital conversion system at ERC. These programs are designed to handle data records with 160 samples per channel per record on the digital tape. Up to eight channels may be accommodated by the basic input programs.

There are two basic steps to the graphic analysis system:

STEP 1 : Demultiplex the N-channel data tape onto N separate files. Each of these output files will then have a single channel of data in order to facilitate future analysis. These files may be used internally by a series of analysis programs, or they may be saved on tape for future use, thus saving the step 1 procedure.

STEP 2 : These programs do some analysis of the raw data.

BLOOD PRESSURE

STEP 2.1: The blood pressure data can be plotted as systolic, mean and diastolic pressure; the heart rate is also computed and plotted from the same data on the same graph.

RESPIRATION RATE

STEP 2.2: This subroutine will compute and plot respiration rate from the data on chest expansion. (Note that these rate calculations may be used for any general rate computation on any slowly varying data).

TEMPERATURE DATA

STEP 2.3: Two channels of data include subcutaneous temperature information and deep body temperature. Both of these temperatures will be plotted with the same time axis so that their relative changes can be observed and correlated.

DETAILED USER INSTRUCTIONS

STEP 1

There are only two parameters which the user must supply to the STEP 1 program; all other parameters are a result of the basic assumption that the data tape has 160 samples per channel per record. Thus, the program only needs to know: (1) N -- the number of channels of data, and (2) whether time code is included or not.

This information is supplied to STEP 1 by one data card containing the number of channels (from 1 to 8) in column 1, and a 1 in column 2 if time code is included (no time code assumed for any other value).

The READ statement looks like this:

```
      READ 1,NCHAN,ITIME
1     FORMAT(2I1)
```

SUMMARY OF VALUES FOR NCHAN AND ITIME

NCHAN = 1,2,3,4,5,6,7,8

ITIME = 1 time code included
$\neq$ 1 no time code

Given this information the program will proceed to read the data tape called TAPE1 and write single channel files TIME, TAPE11, TAPE12,...,TAPE (10+NCHAN). where time code becomes file TIME,

Channel 1 becomes file TAPE11,
Channel 2 becomes TAPE12,
etc.

See Table 1 for a summary of channel to files produced by program STEP1.

STEP 2

There are two ways to control the STEP2 program. First the user must decide which data channels correspond to which data types (blood pressure, respiration, subcutaneous temperature and deep body temperature). STEP2 will assume, unless otherwise instructed, the channel assignments summarized in TABLE 2.

It is very easy to change the channel assignments at the time STEP2 is loaded. The loader allows us to change the external name of a file name included on the Program card of a FORTRAN program. For example, the Program card for STEP2 looks like:

```
PROGRAM STEP2(TAPE11,TAPE12,TAPE13,TAPE14,...)
```

The following discussion assumes that we will execute a binary deck of the program STEP2, which will be a record in the normal INPUT card stream. As such, we can run STEP2 with the default file assignments of TABLE 2 with the control card:

INPUT.

The first four files names TAPE11 through TAPE14 are the files to be read to obtain the data to be plotted according to TABLE 2. To instruct STEP2 to get blood pressure data off TAPE15 (see Table 1) the user "replaces" TAPE11 with TAPE15 at loading time of STEP2:

INPUT,TAPE15.

If respiration were on channel 6 instead of channel 2, the user uses the control card:

INPUT,,TAPE16.

Thus it is easy to produce the proper graphs for any arbitrary channel assignments of the original data. As one last example suppose channel 3 had respiration data and channel 2 had subcut eous temperature. The user can have these files properly plotted by the control card:

INPUT,,TAPE13,TAPE12.

Note that file assignments which are not to be changed may be either left blank or replaced with the standard file, causing no changes. Thus the above card could be punched as:

INPUT,TAPE11,TAPE13,TAPE12.

Also note that the position is important. Each file name (or blank) must be separated by commas. Thus the following control cards will produce different results:

INPUT,TAPE13,TAPE12.
INPUT,,TAPE13,TAPE12.

For further examples and for control card summaries see the appendix.

The only other information needed by the program STEP2 is which displays (blood pressure, respiration and temperature) are desired. Any combination of plots may be produced. STEP2 will read one data card with three integers in columns one, two and three. The results produced are summarized in Table 3. Thus the data card to produce blood pressure and respiration displays would be:

110

See the appendix for further examples.

TABLE 1

Summary of channel to file transformations produced by program STEP 1.

CHANNEL (ON TAPE 1)	RESULTING FILE (AFTER STEP 1)
1	TAPE11
2	TAPE12
3	TAPE13
4	TAPE14
5	TAPE15
6	TAPE16
7	TAPE17
8	TAPE18
TIME CORE	TIME

TABLE 2

Summary of Standard Channel assignments according to data types assumed by program STEP 2.

CHANNEL NUMBER	DATA TYPE	STANDARD FILENAME (AFTER STEP1)	POSITION ON STEP2 PROGRAM CARD
1	Blood Pressure	TAPE11	1
2	Respiration	TAPE12	2
3	Subcutaneous Temperature	TAPE13	3
4	Deep Body Temperature	TAPE14	4

TABLE 3
CONTROL OF DISPLAYS IN STEP2

DATA CARD COLUMN	VALUE	RESULTS
1	≠1	No blood pressure display
	=1	Blood pressure displayed
2	≠1	No respiration display
	=1	Respiration displayed
3	≠1	No temperature display
	=1	Temperature displayed

APPENDIX

SAMPLE CONTROL CARD SETUPS FOR PRODUCING DISPLAYS

EXAMPLE 1

execute the two job steps in one computer run, use the following deck setup:

```
-CARD,...,MT1,...,CM50000.
-,100.
QUEST,TAPE1,VSN=D0068,S,READ.NAME
-,40000.
-UT.  This is STEP 1 to demultiplex raw data.
--URN.TAPE1.
-,50000.
-UT.  This is STEP 2 to produce displays.
-/9
      (Binary deck for STEP 1)
-/9
      (Data for program STEP 1)
-/9
      (Binary deck for STEP 2)
-/9
      (Data for program STEP 2)

-/8/9
```

-s deck will process a channel data tape with time code, and produce -od pressure, respiration and temperature displays.

EXAMPLE 2

This example demonstrates how to produce the displays by creating a single tape of the demultiplexed data in the first part. This tape is then used to produce plots in the second part.

PART 1

To process the original 6 channel data tape with time code and produce another tape with the demultiplexed data as separate files.

```
JOBCARD,ACCOUNT,CM40000,MT1,....
RFL,100.
REQUEST,TAPE1,VSN=D0068,S,READ,NAME
RFL,40000.
INPUT.
RFL,10000.
REWIND,TAPE11,TAPE12,TAPE13,TAPE14,TAPE15,TAPE16,TIME.
UNLOAD,TAPE1.
REQUEST,TAPE,VSN=DXXX,WRITE,MCCARTHY
COPY,TIME,TAPE.
COPY,TAPE11,TAPE.
COPY,TAPE12,TAPE.
COPY,TAPE13,TAPE.
COPY,TAPE14,TAPE.
COPY,TAPE15,TAPE.
COPY,TAPE16,TAPE.
7/8/9
   (Binary deck program STEP 1)
7/8/9
61 (Data for STEP 1)
6/7/8/9
```

PART 2

Use the tape generated by Part 1 to produce displays. Assume channel 6 has blood pressure data.

```
JOBCARD,ACCOUNT,CM50000,MT1,...
RFL,10000.
REQUEST,TAPE,VSN=DXXX,READ.
COPYBF,TAPE,TIME.
COPYBF,TAPE,TAPE11.
COPYBF,TAPE,TALE12.
COPYBF,TAPE,TAPE13.
COPYBF,TAPE,TAPE14.
COPYBF,TAPE,TAPE15.
COPYBF,TAPE,TAPE16.
REWIND,TIME,TAPE11,TAPE12,TAPE13,TAPE14,TAPE15,TAPE16.
RFL,40000.
INPUT,TAPE16.
7/8/9
```

```
   (Binary deck of STEP 2)
7/8/9
   (Data for STEP 2)
6/7/8/9
```

EXAMPLE 3

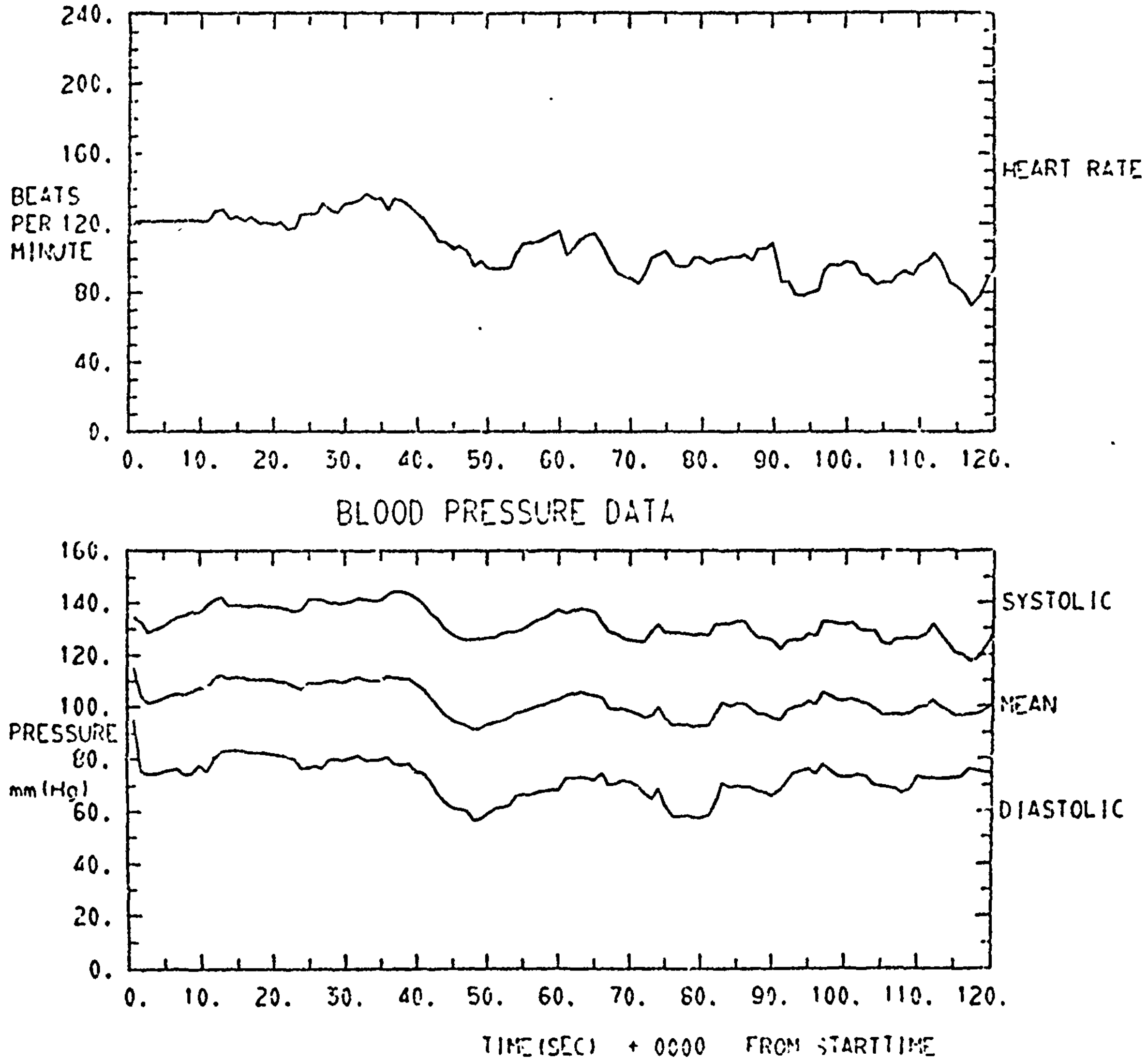
In one job produce blood pressure and temperature plots, but not respiration. Assume 6 channels with time code, but use non-standard channel assignments.

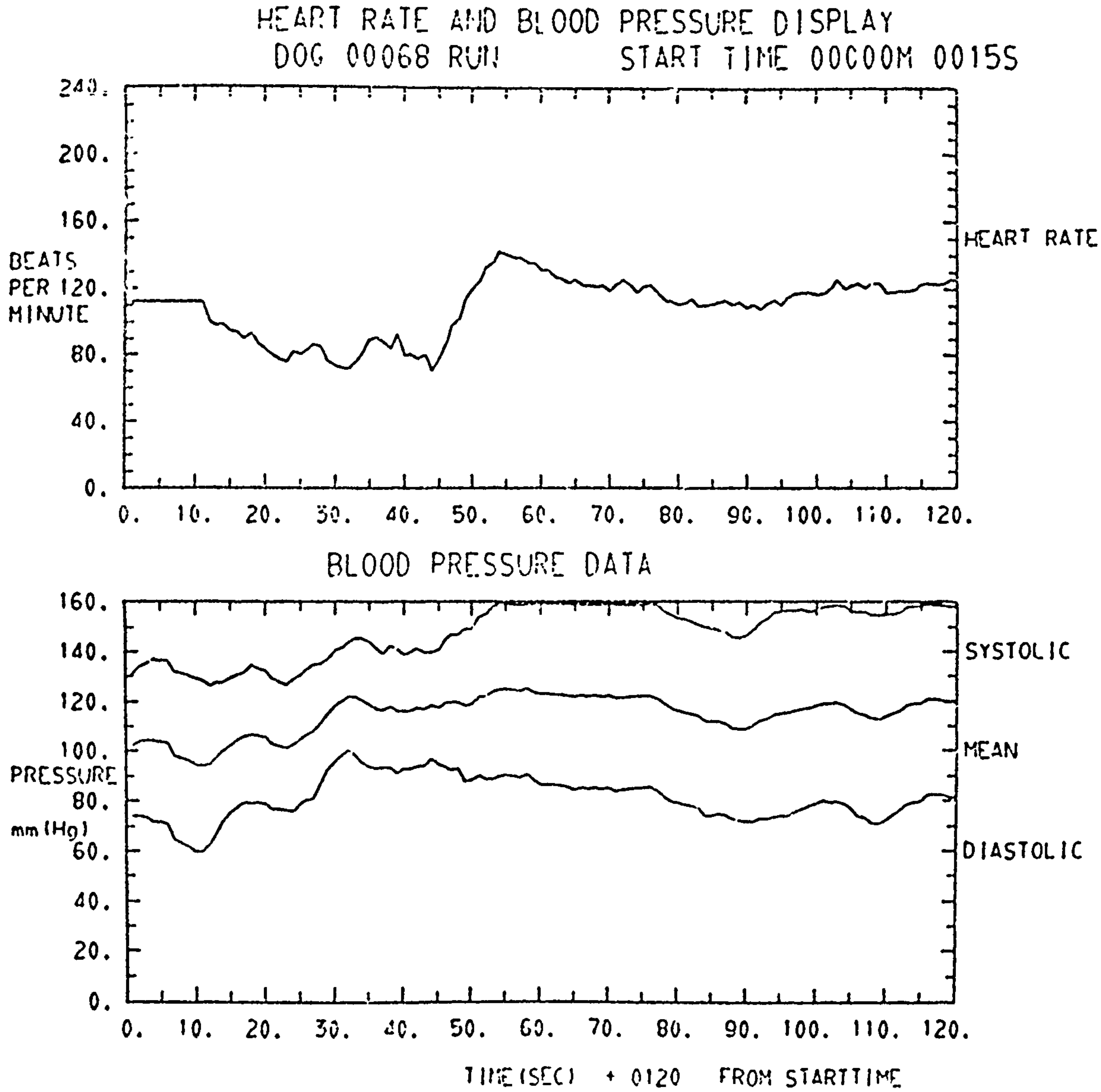
Channel 2 is blood pressure
Channel 5 is ~~blood pressure~~ [illegible]
Channel 6 is subcutaneous temperature

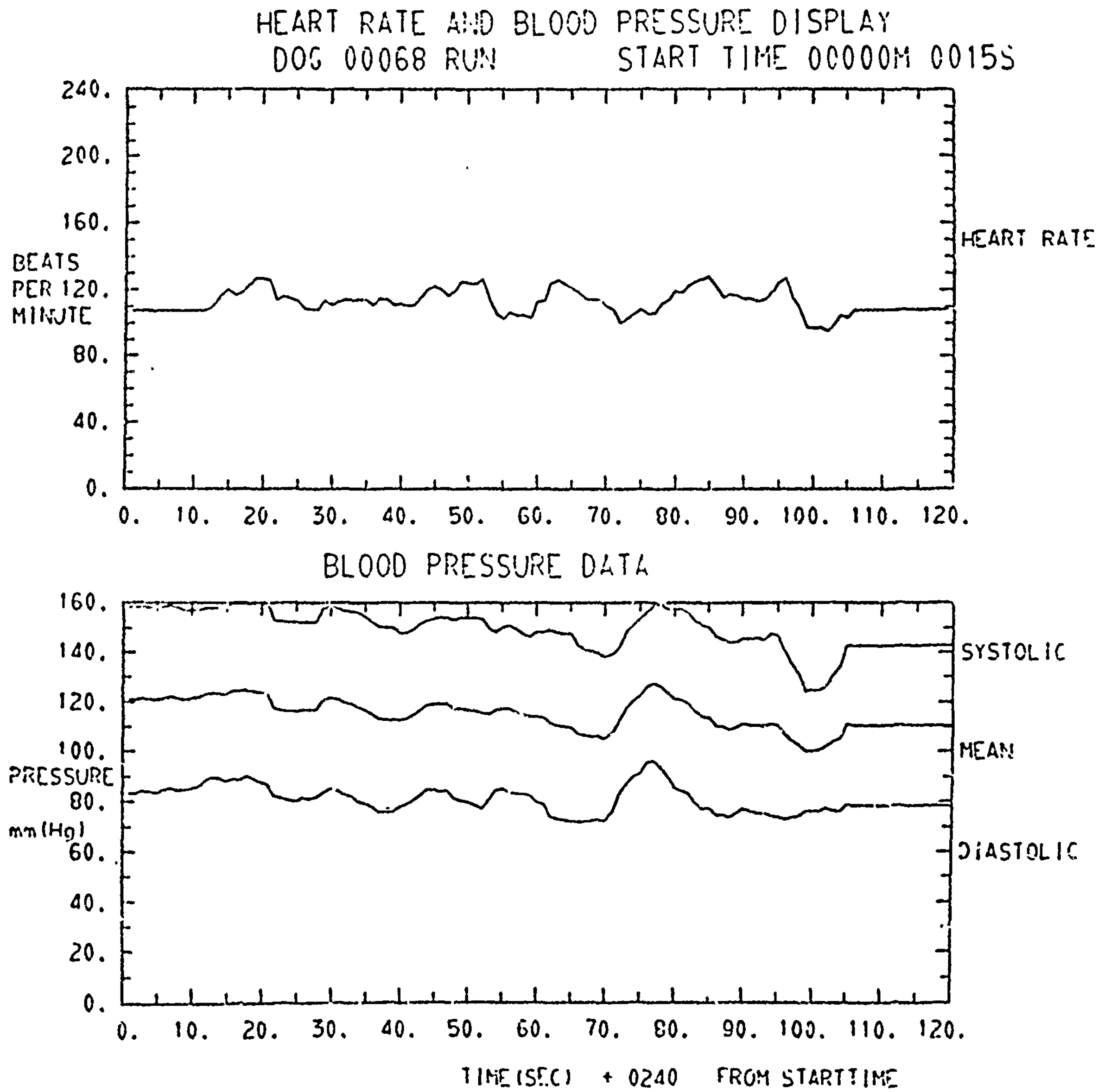
```
JOBCARD,ACCOUNT,CM50000,MT1,....
RFL,100.
REQUEST,TAPE1,VSN=D068,S,READ.NAME
RFL,40000.
INPUT.
RETURN,TAPE1.
RFL,5000.
INPUT,TAPE12,,TAPE16,TAPE15.
7/8/9
   (Binary deck for STEP 1)
7/8/9
61 (Data for STEP 1)
7/8/9
   (Binary deck for STEP 2)
7/8/9
101 (Data for STEP 2)
6/7/8/9
```

HEART RATE AND BLOOD PRESSURE DISPLAY

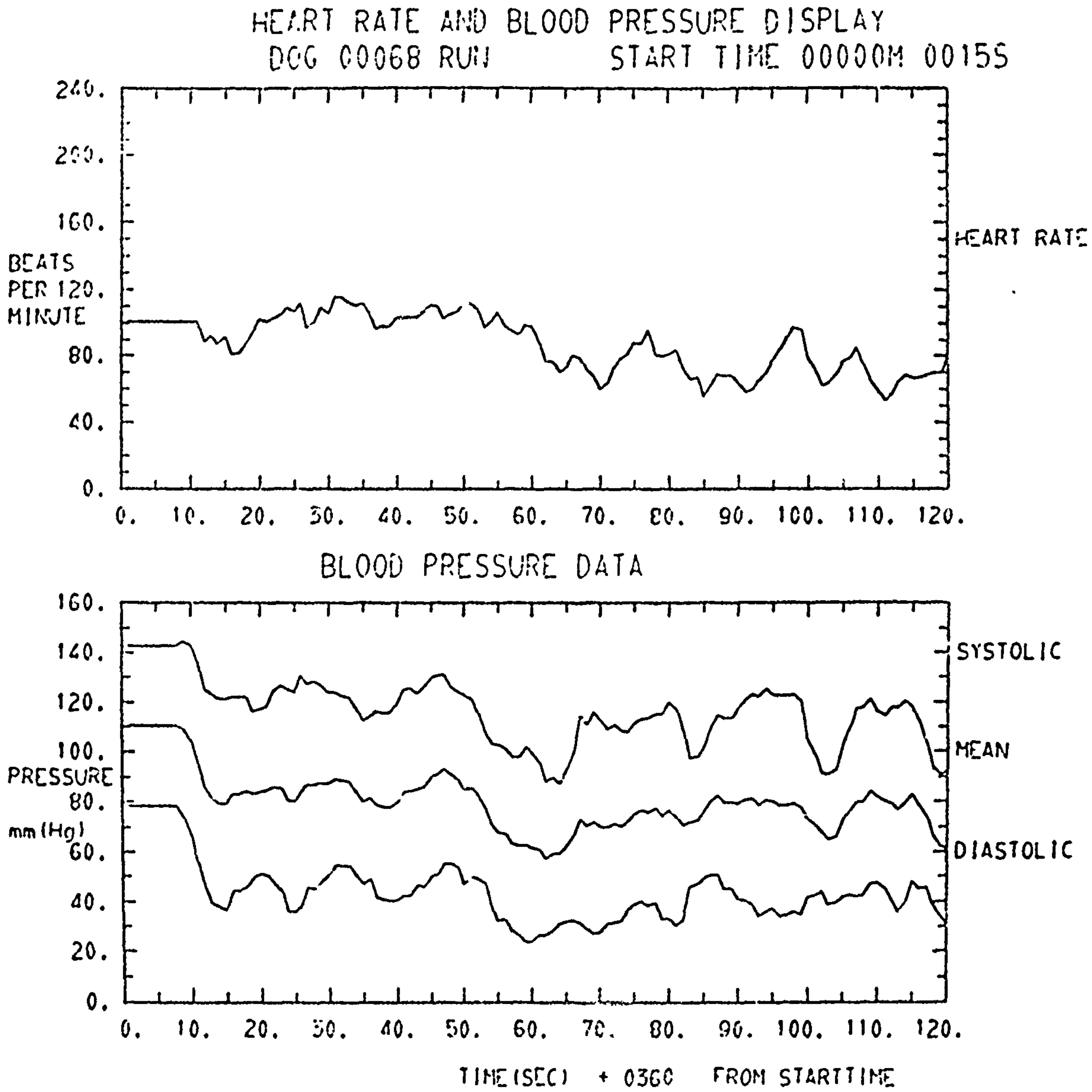
DOG 00068 RUN   START TIME 00000M 0015S




HEART RATE AND BLOOD PRESSURE DISPLAY
DOG 00068 RUN START TIME 00C00M 0015S
240.
200.
160.
BEATS PER MINUTE
120.
80.
40.
0.
HEART RATE
0. 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120.
BLOOD PRESSURE DATA
160.
140.
120.
100.
PRESSURE mm (Hg)
80.
60.
40.
20.
0.
SYSTOLIC
MEAN
DIASTOLIC
0. 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120.
TIME (SEC) + 0120 FROM STARTTIME



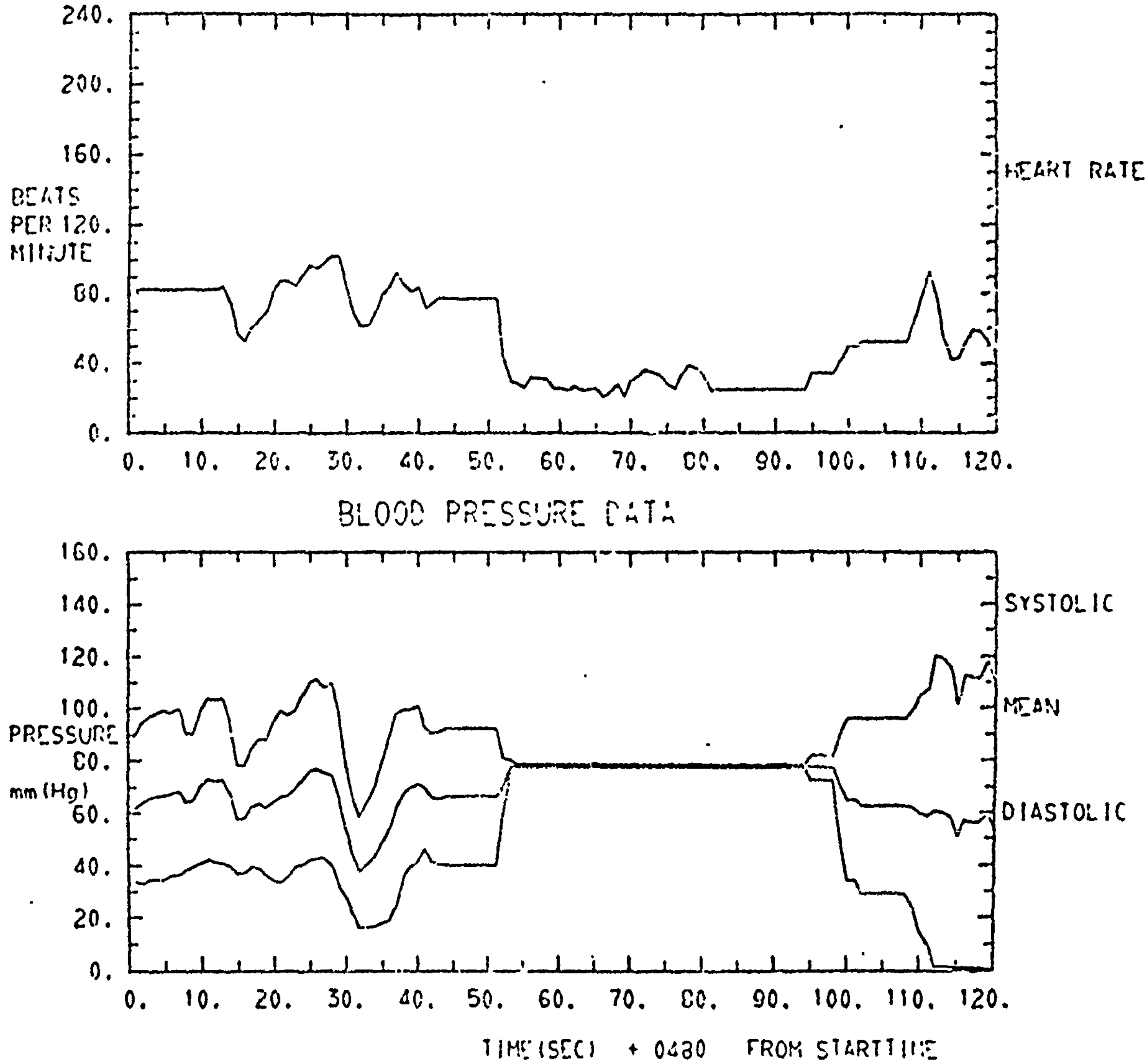
HEART RATE AND BLOOD PRESSURE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S
BEATS PER MINUTE
HEART RATE
0. 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120.
BLOOD PRESSURE DATA
PRESSURE mm(Hg)
SYSTOLIC
MEAN
DIASTOLIC
TIME(SEC) + 0240 FROM STARTTIME

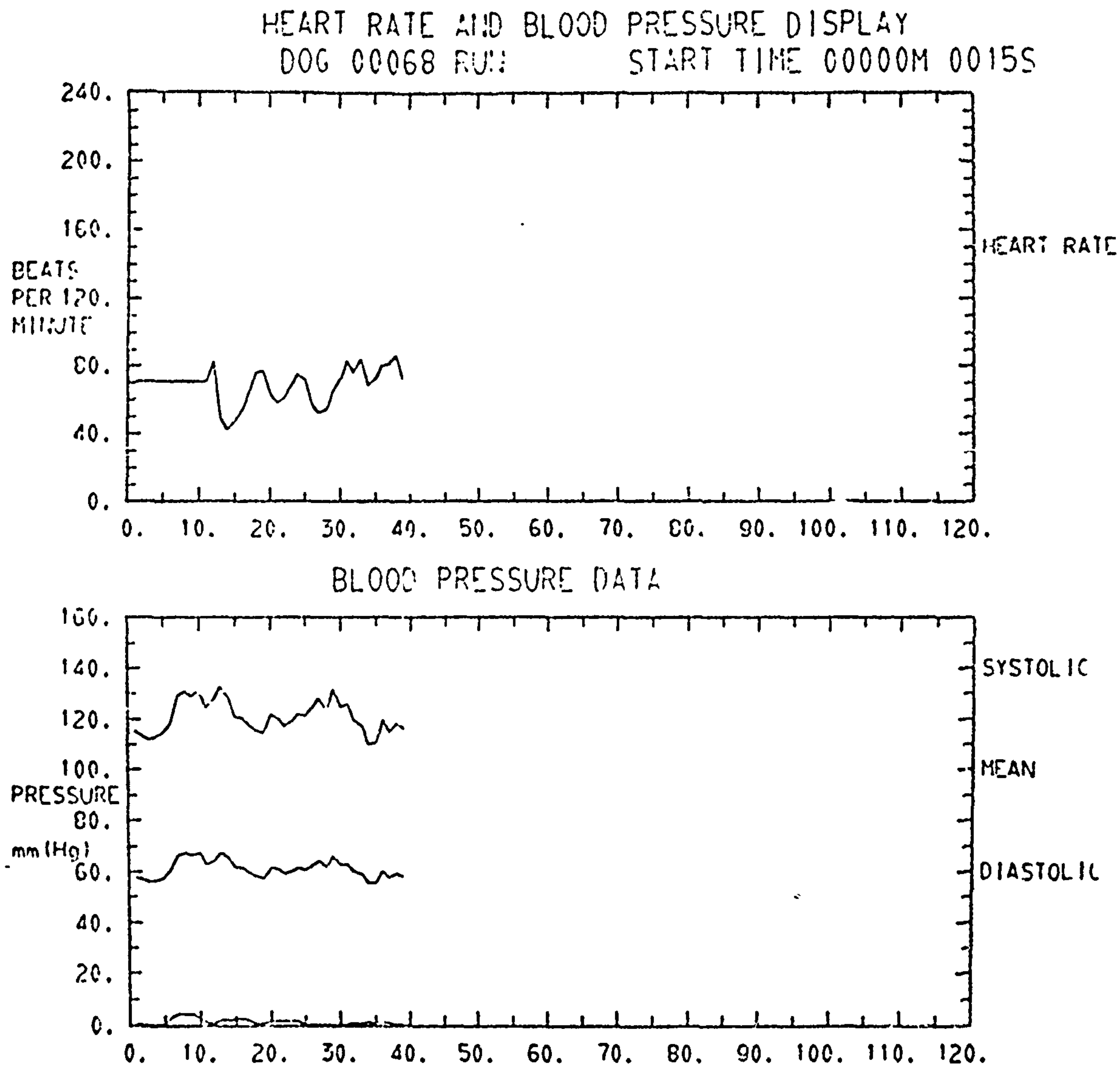


HEART RATE AND BLOOD PRESSURE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S
BEATS PER MINUTE
HEART RATE
BLOOD PRESSURE DATA
PRESSURE mm (Hg)
SYSTOLIC
MEAN
DIASTOLIC
TIME(SEC) + 0360 FROM STARTTIME

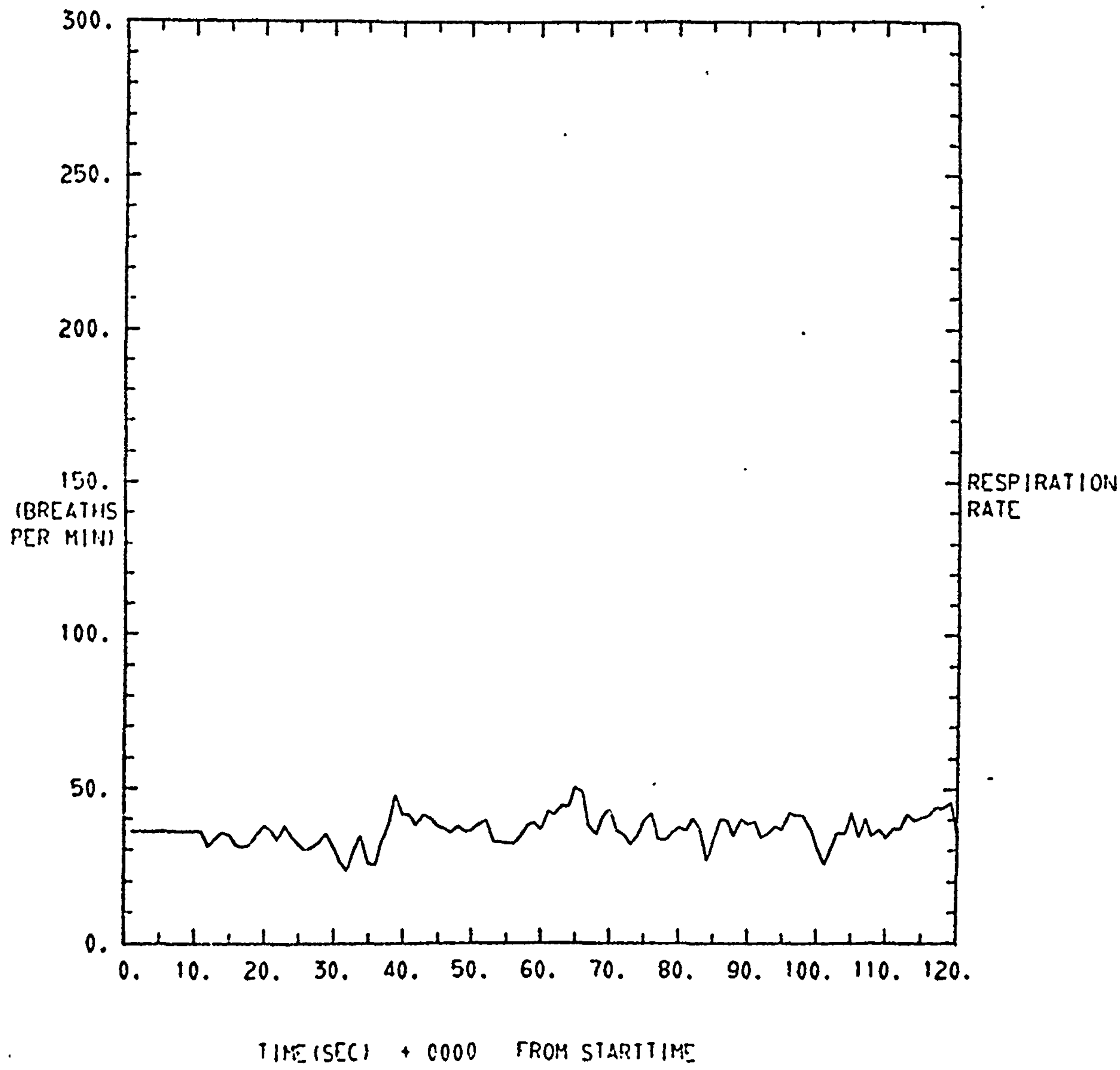
HEART RATE AND BLOOD PRESSURE DISPLAY

DOG 00068 RUN START TIME 00000M 0015S

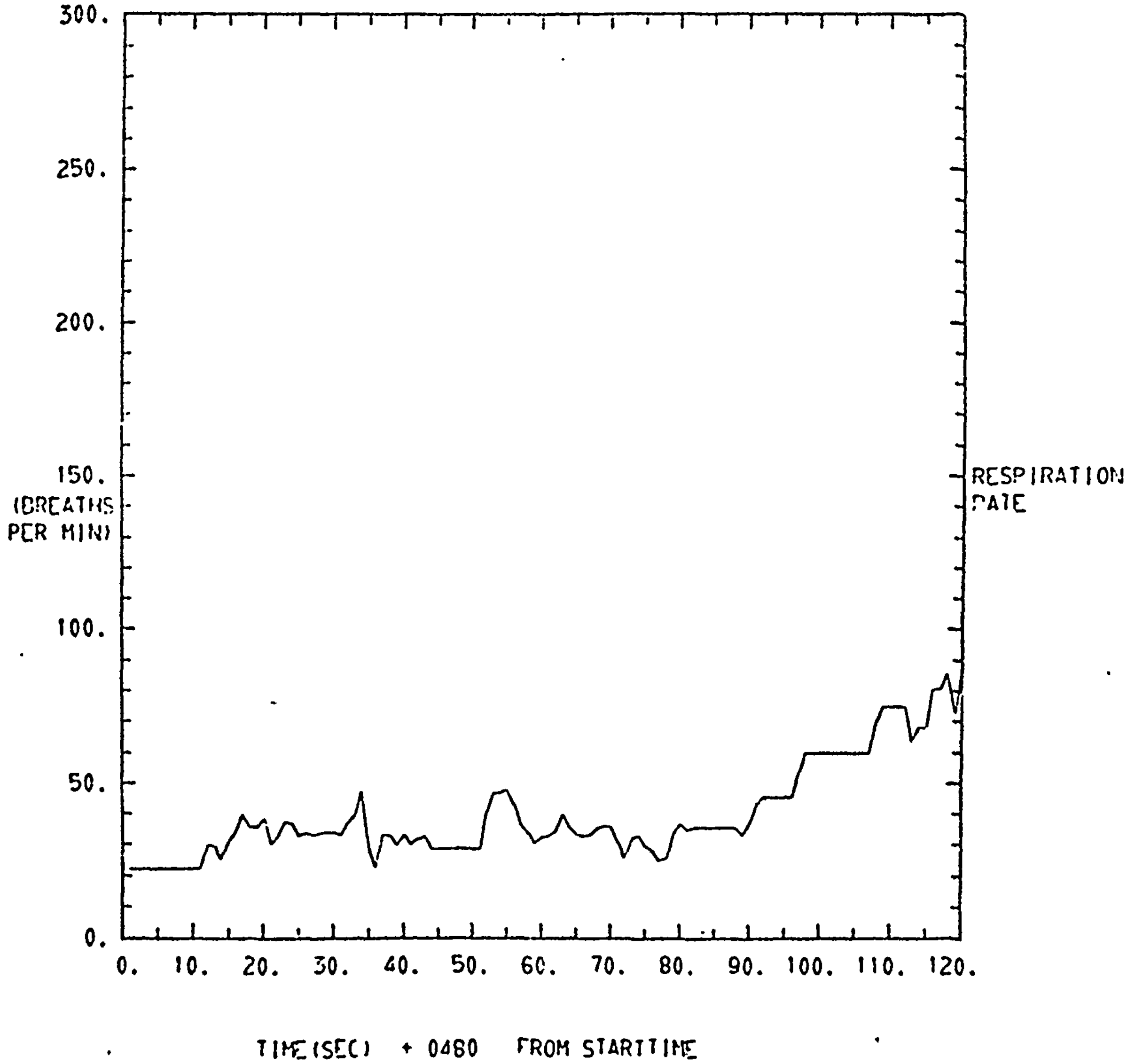


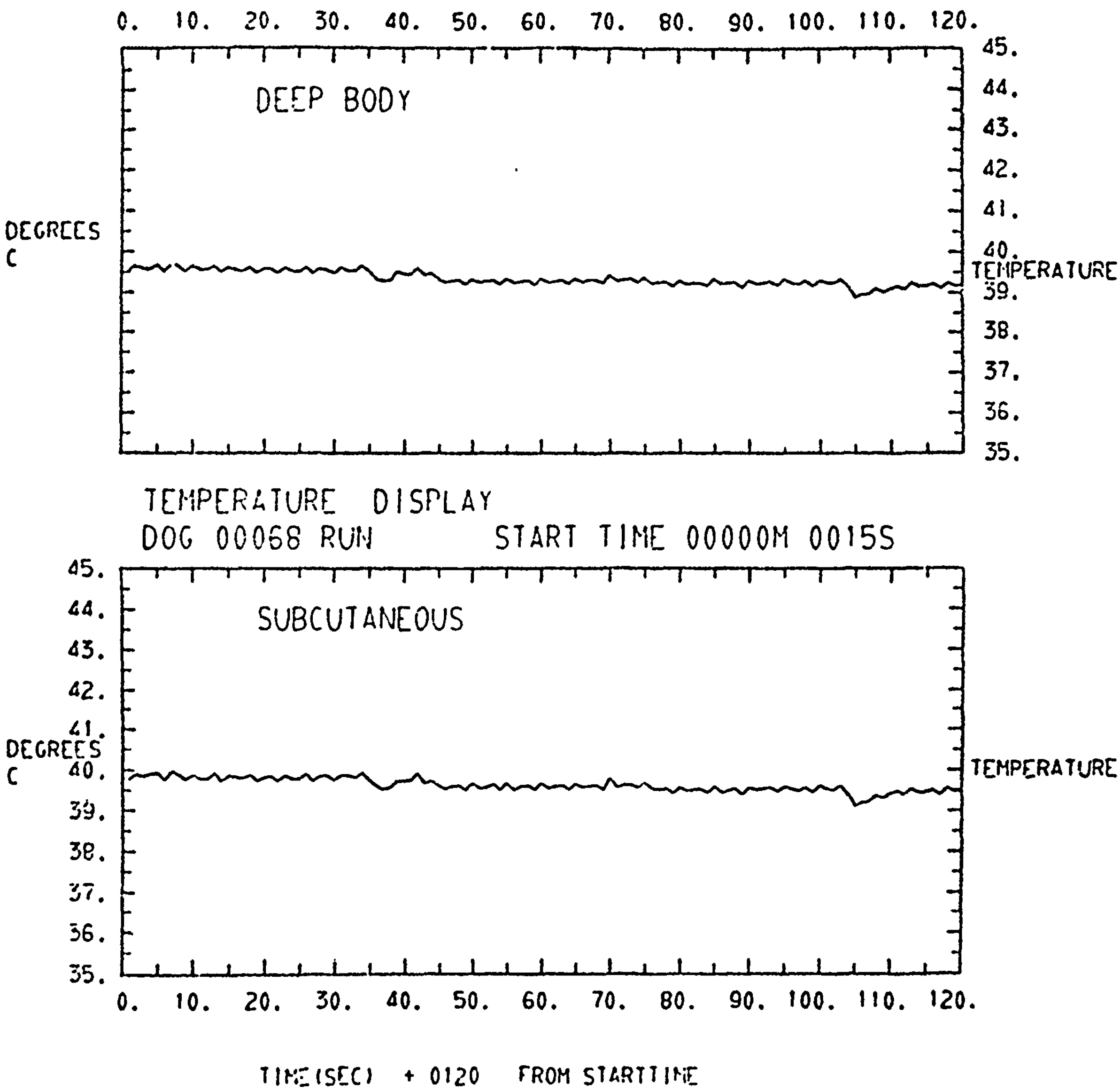

HEART RATE AND BLOOD PRESSURE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S
BEATS PER MINUTE
HEART RATE
BLOOD PRESSURE DATA
PRESSURE mm(Hg)
SYSTOLIC
MEAN
DIASTOLIC
TIME(SEC) + 0600 FROM STARTTIME

RESPIRATION RATE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S

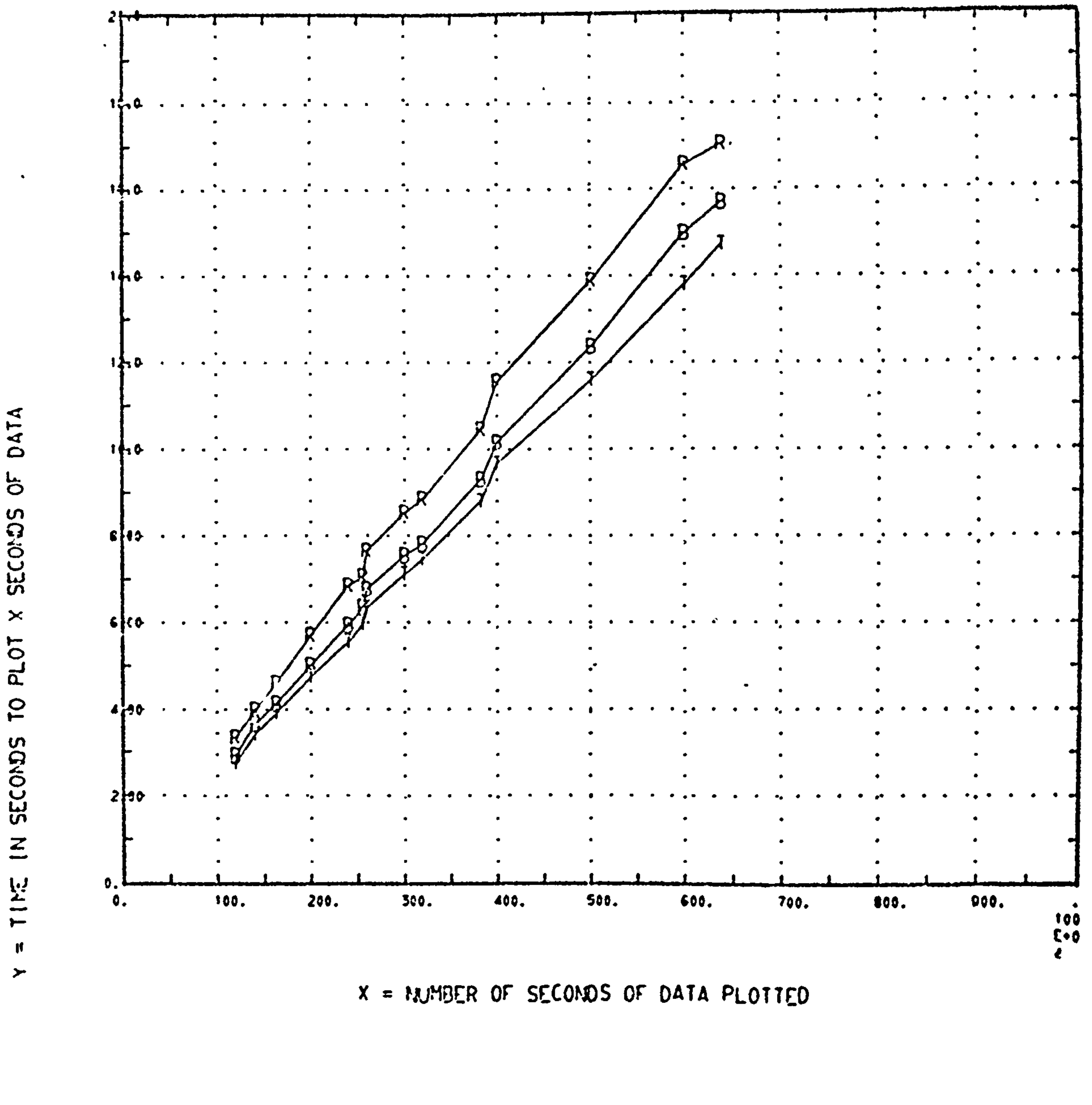


RESPIRATION RATE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S

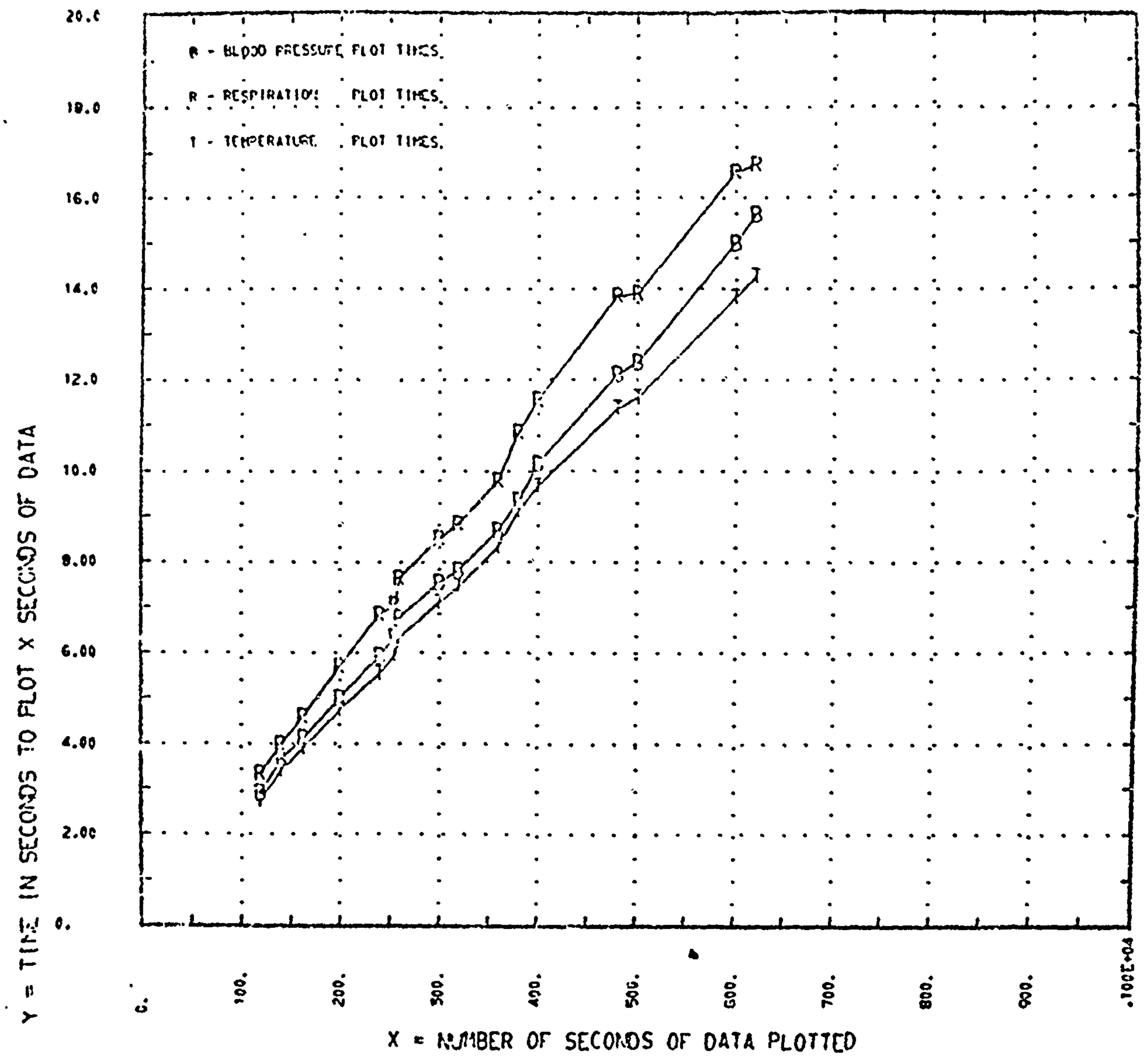



DEEP BODY
DEGREES C
TEMPERATURE
TEMPERATURE DISPLAY
DOG 00068 RUN START TIME 00000M 0015S
SUBCUTANEOUS
DEGREES C
TEMPERATURE
0. 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. 110. 120.
45. 44. 43. 42. 41. 40. 39. 38. 37. 36. 35.
TIME(SEC) + 0120 FROM STARTTIME

TIMING CALIBRATION OF PHYSIOLOGICAL DISPLAY SYSTEM



TIMING CALIBRATION OF PHYSIOLOGICAL DISPLAY SYSTEM



AUXILIARY PROGRAMS FOR THE DOG PHYSIOLOGICAL DATA GRAPHIC DISPLAY SYSTEM

STEP0

This is a program which allows the user to create a continuous data tape from the many files which might be produced by the REDCOR conversion system. STEP0 reads the raw data from TAPE2 and writes one file on TAPE1. STEP0 reads one data card containing the number of seconds of data to be written onto the output tape. STEP0 assumes a six channel data tape with time code, the sampling rate of 250 samples per channel per second and the record length of 160 samples per channel per second. Thus the number of records desired is:

NREC=250*NSECS/160

The FORTRAN code will require minor changes in order to handle different numbers of channels, time code, sampling rate and record length. NOTE: STEP0 is strictly designed to precede STEP1.

STEP3

This program is designed to allow the user to observe the actual data values of any data channel in a format similar to that produced by STEP2. In particular, the data is displayed in frames containing 120 seconds (2 minutes) of data each until the end of file. The data is displayed as 6 curves each containing 20 seconds of data (representing 5000 data samples which have been averaged in groups of 5 producing 1000 actually plotted points). Each of the six curves is labeled at the ends with the relative time within the frame. Thus, the observer noting some irregularity in the STEP2 results has the ability to observe the raw data at the time of interest to determine the nature of the problem.

Since STEP2 is the primary program in the Graphic Display System, STEP3 has been designed to analyse one channel of data at a time. If the results from STEP2 are satisfactory, it will be unnecessary to run any STEP3 plots.

STEP3 has one data card which allows the user to create a user label which is included as the third line in the title of the frame. Thus if the user wishes to further describe the data to be plotted, he can. This label may be a blank card if desired.

The label itself may be up to 60 characters long. STEP3 assumes records containing 160 samples per second at a rate of 250 samples per channel per second. NOTE: STEP3 will only work with files created by STEP1.

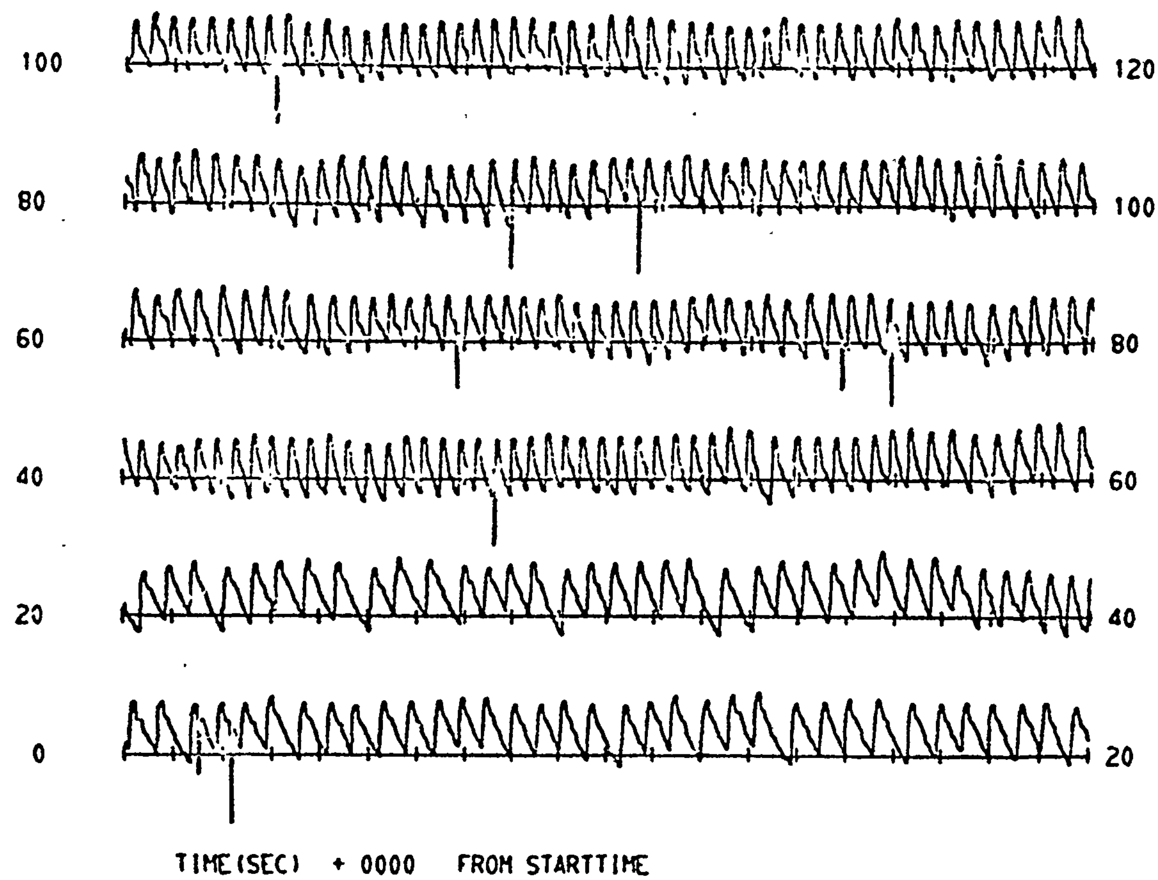
Example using STEP0, STEP1, STEP3 to plot channels 1 and 2.

```
XY013,ABCDEFGH,CM60000.
RFL(100)
REQUEST(TAPE2,VSN=D0068,S,READ)NAME
RFL(30000)
MAP(OFF)
LOAD(INPUT)...(FOR STEP0)
LGO.
REWIND(LGO)
RFL(30000)
LOAD(INPUT)    (FOR STEP1)
LGO.
RETURN(LGO)
RFL(60000)
LOAD(INPUT)
LGO.           (FOR STEP3 with TAPE11=channel 1 data)
RFL,60000.
LGO(TAPE12)    (For STEP3 with TAPE12=channel 2 data)
7/8/9
   (STEP0 binary deck)
7/8/9
500            (STEP0 data: Number of seconds of data desired)
7/8/9
   (STEP1 binary deck)
7/8/9
61 (STEP1 data)
7/8/9
   (STEP3 binary deck)
7/8/9
THIS IS CHANNEL1 DATA  (STEP3 data: User Label)
7/8/9
THIS IS CHANNEL2 DATA  (STEP3 data:  User Label)
6/7/8/9
```

RAW DATA DISPLAY

DOG 00068 RUN START TIME 00000M 0015S

DOG TAPE NUMBER D-68 CHANNEL 1

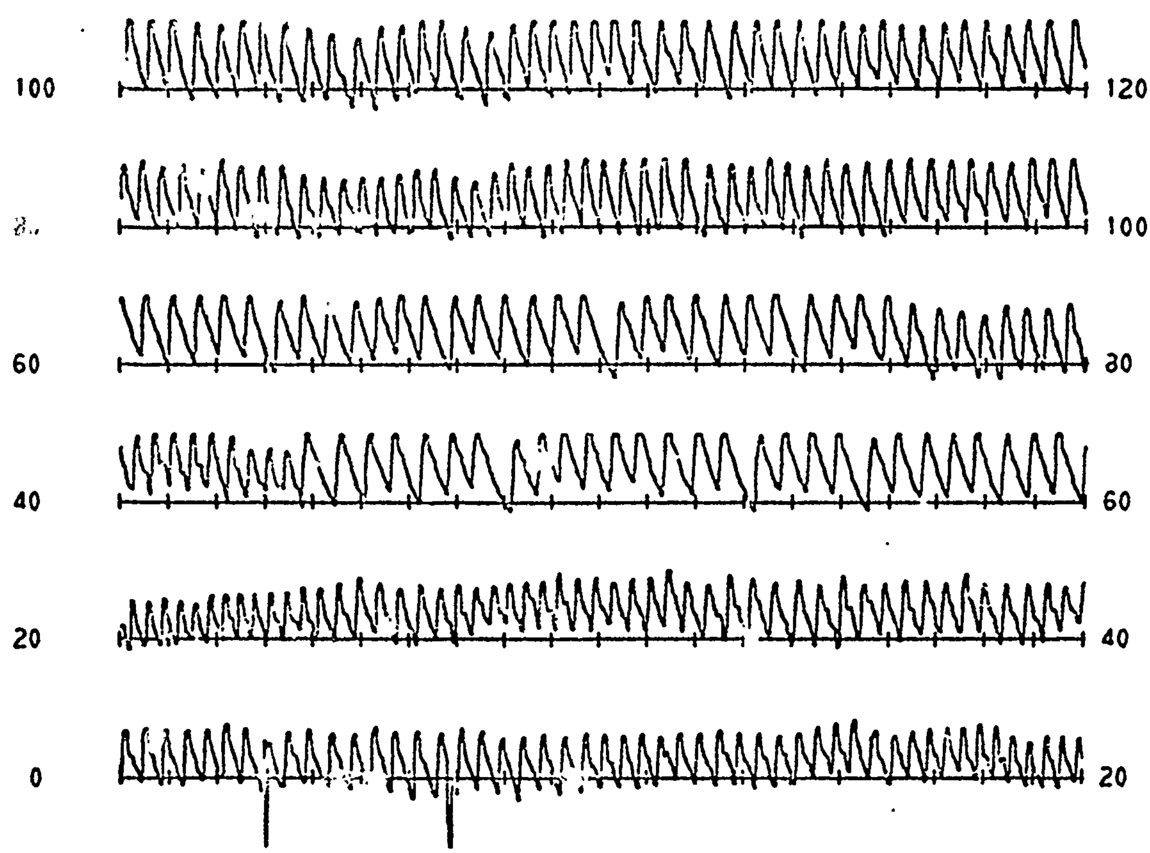


DATA FROM SCOPE FILE TAPE11

RAW DATA DISPLAY

DOG 00068 RUN START TIME 00000M 0015S

DOG TAPE NUMBER D-68 CHANNEL 1

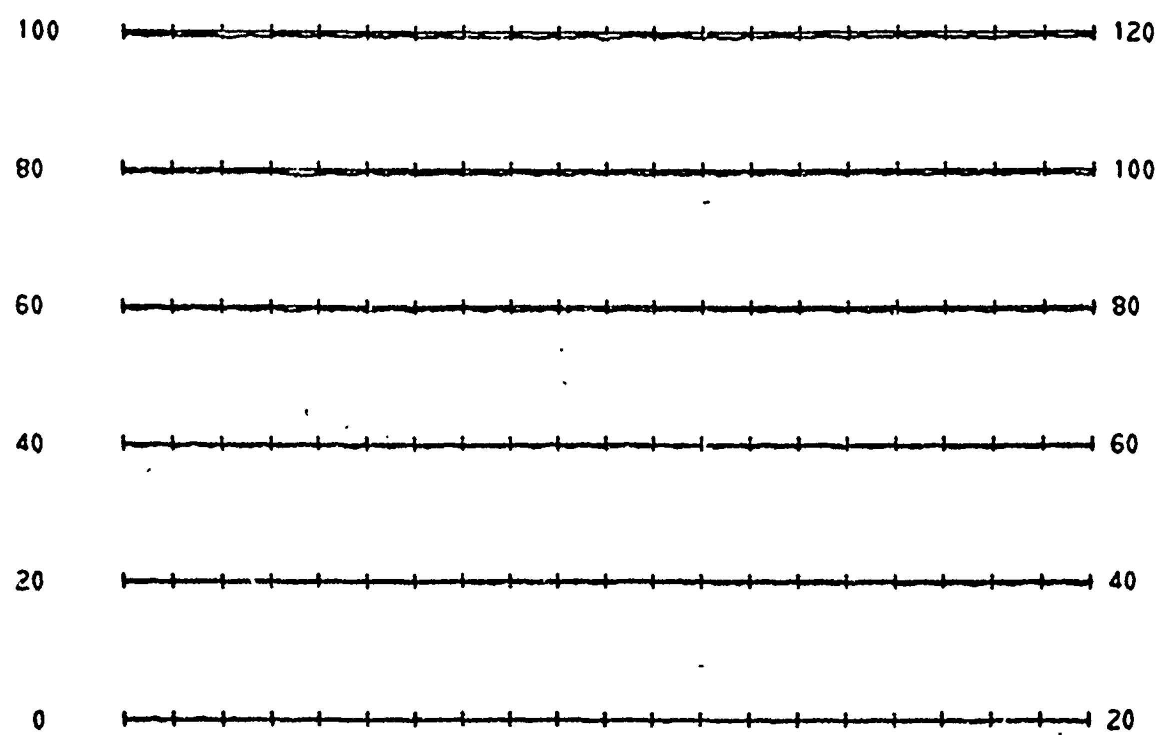


TIME(SEC) + 0120 FROM STARTTIME

DATA FROM SCOPE FILE TAPE11

RAW DATA DISPLAY
DOG 00068 RUN START TIME 00000M 0015S

DOG TAPE NUMBER D-68 CHANNEL 2

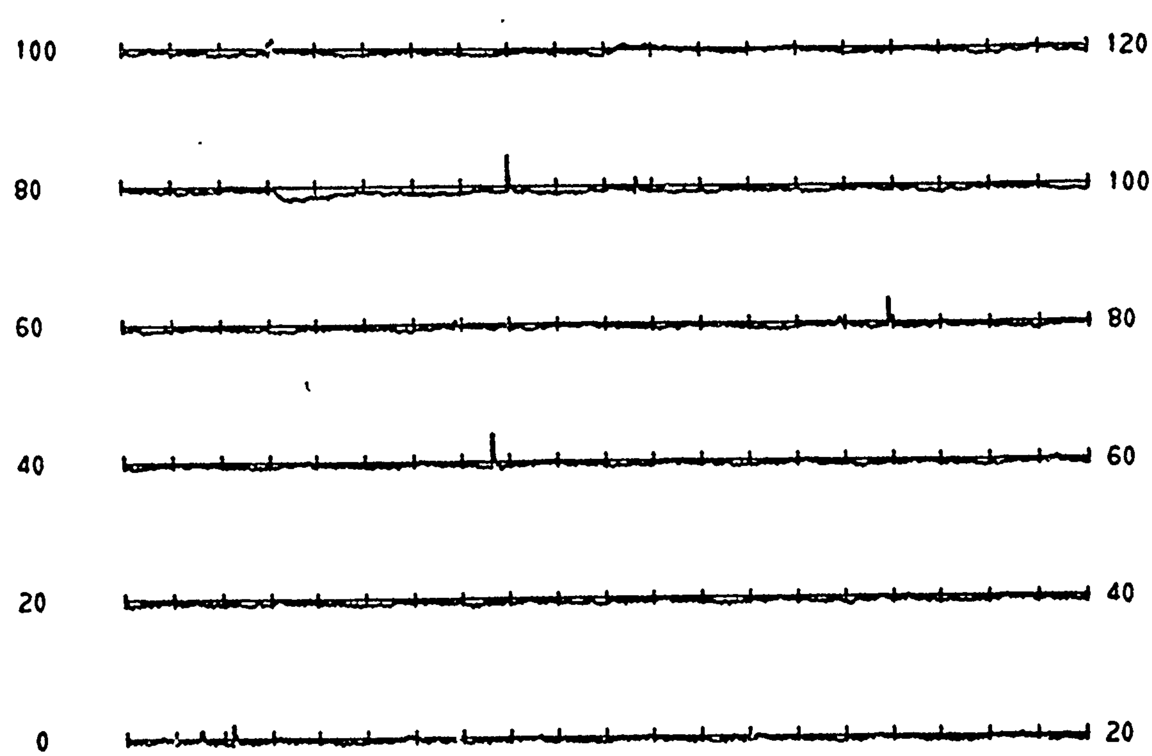


TIME(SEC) + 0000 FROM STARTTIME

DATA FROM SCOPE FILE TAPE12

RAW DATA DISPLAY
DOG 00068 RUN START TIME 00000M 0016S

DOG TAPE NUMBER D-68 CHANNEL 3



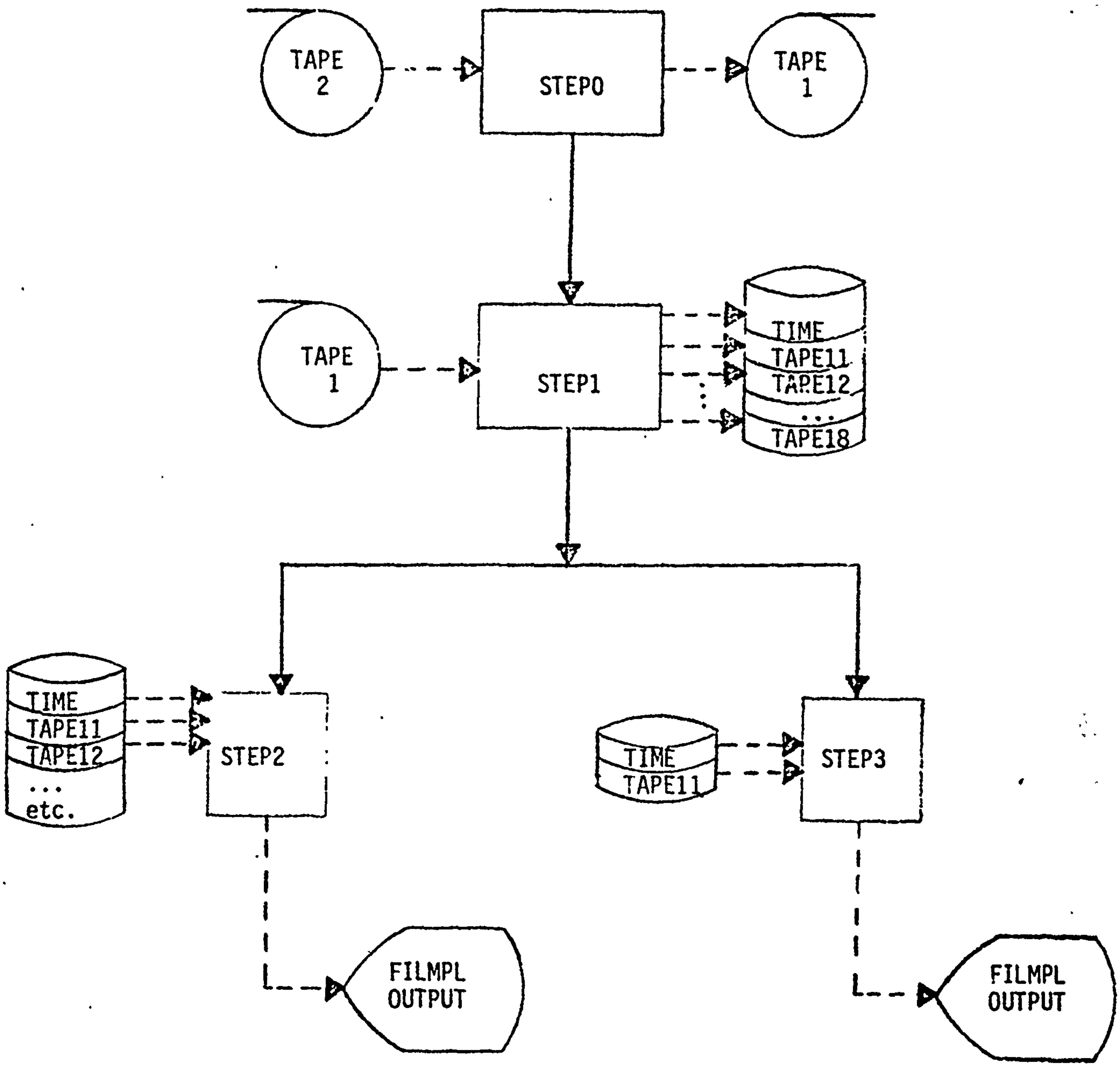
TIME(SEC) + 0000 FROM STARTTIME

DATA FROM SCOPE FILE TAPE13

DOG PHYSIOLOGICAL DATA

GRAPHIC DISPLAY SYSTEM

DATA FLOW ANALYSIS



NOTE: Each STEP requires some information from CARD INPUT, as described in the User Documentation, for program control.